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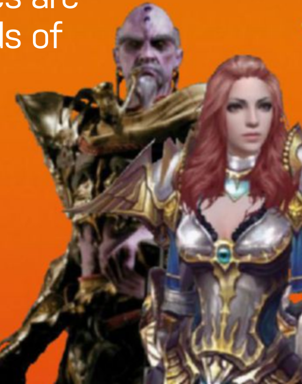

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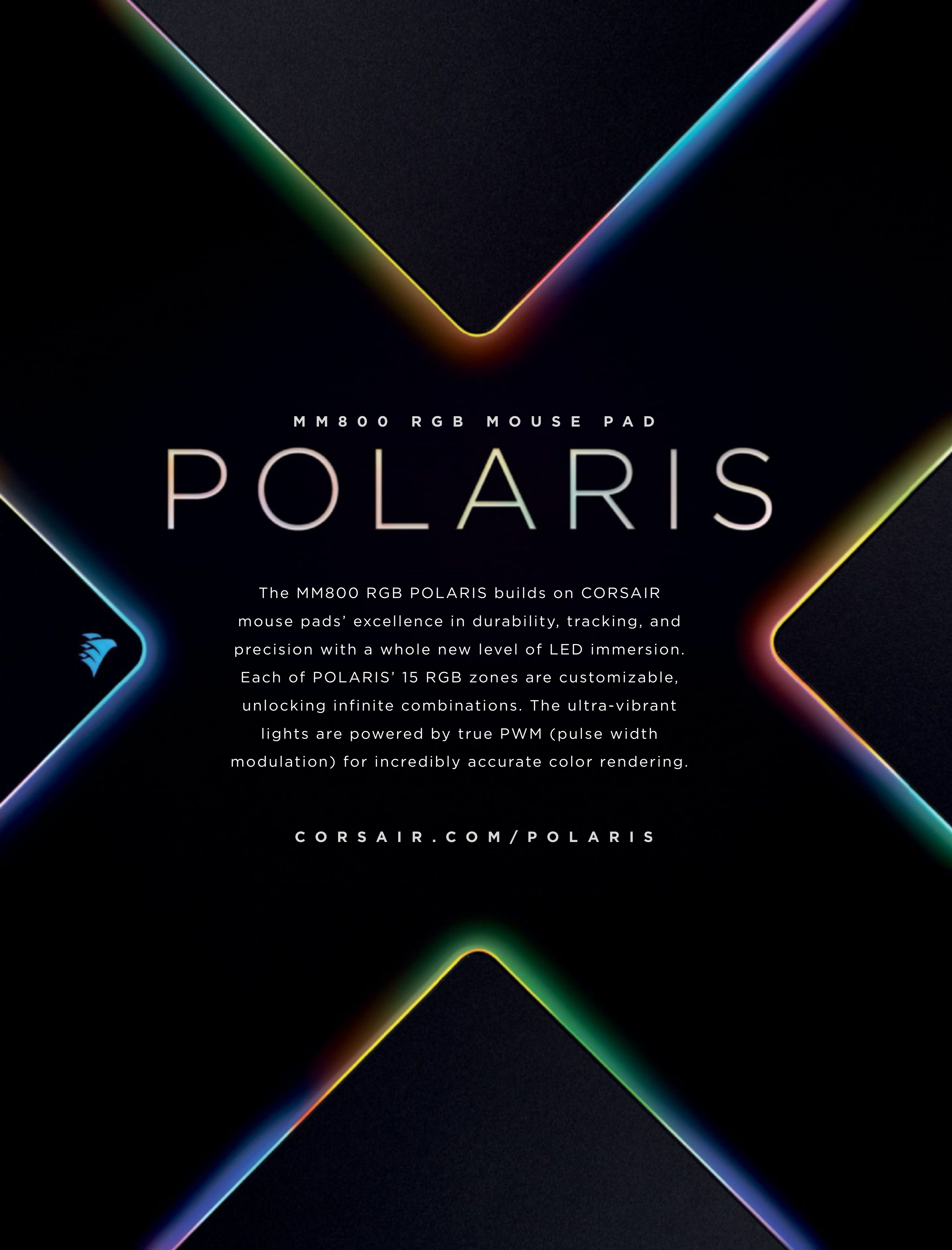

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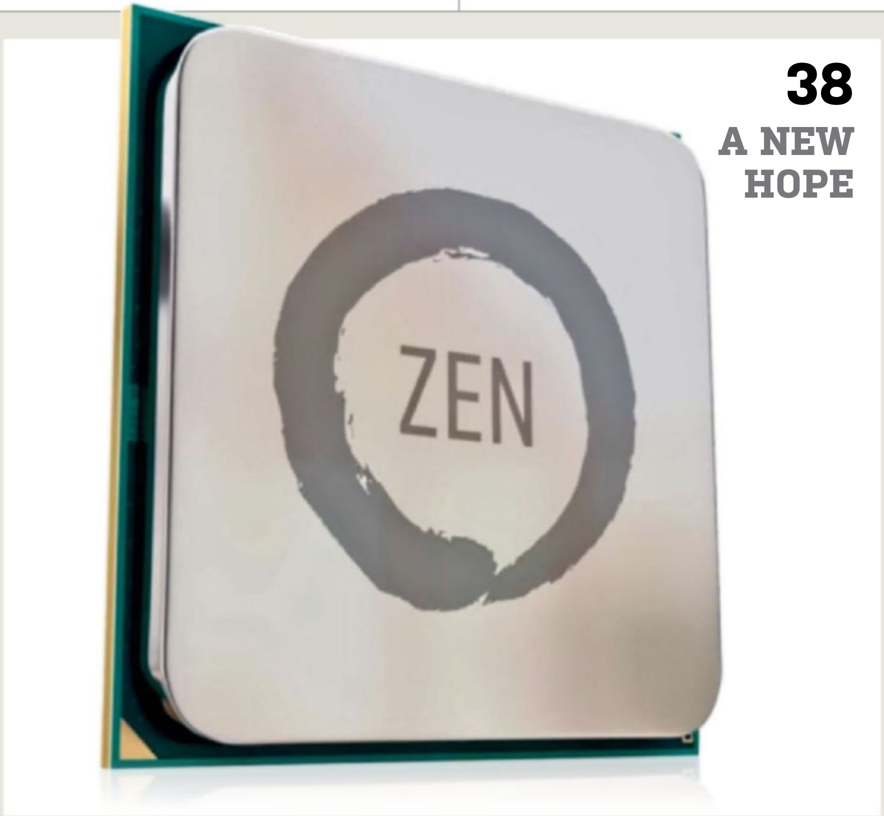

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ART
Art Editor: Fraser McDermott
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BUSINESS
Vice President, Sales: Stacy Gaines, stacy.gaines@futurenet.com
Vice President, Strategic Partnerships: Isaac Ugay, isaac.ugay@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Brandon Wong, brandon.wong@futurenet.com
West Coast Account Director: Tad Perez, tad.perez@futurenet.com
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Tuan
Nguyen

A FASTER CPU FOR FREE? YES PLEASE!

FOR AS LONG as I can remember, I've never used anything exactly as it was intended. And ever since I've owned a computer, I've continued to experiment.

For instance, remember ISA soundcards? They used to come with SIMM slots, to which you could add memory modules. The Sound Blaster AWE 32, for example, was a beast of a card—even larger than the biggest desktop graphics cards available today—and it could take extra memory, enabling you to load it with sound samples, specifically for MIDI playback. Higher quality instrument samples made everything sound better—so, obviously, I couldn't just leave the AWE 32 in its natural state; I simply had to add some more memory.

In fact, everything in my system had to be tweaked. The CPU, though, was my primary focus, because it had the biggest impact. I had to squeeze out the best performance the system could possibly achieve before overheating. Back then, you had to use jumpers on the motherboard to overclock. There were no Windows programs, and no in-BIOS utilities to make it easy. Though, truth be told, today's BIOS options are so complex, it's actually more difficult than before—which is where we come in.

There are now more overclocking options in the BIOS than you can shake a silicon stick at. You can tweak everything from uncore frequency, to Vcore, and even SpeedStep. Of course, you could let the BIOS do the overclocking for you, but default BIOS profiles always try to play things safe. To really release the oomph that's hidden inside your CPU, you'll want to dive into the nitty gritty of it all. And depending on the luck of the draw when it comes to your specific CPU, you should be able to get quite a bit of extra performance out of it.

The same holds true for GPUs. Not all GPUs are the same, and even with seemingly-identical cards, the GPUs can have totally different overclocking identities. With the GPU, however, things are a lot less complex. There's only a handful of programs that let you properly overclock a GPU. You could modify a graphics card's BIOS to overclock a GPU, but it's a bad idea. If you mess up, there's no rebooting a few times for the BIOS to revert to a backup, or lower itself to stable defaults. You're left with a useless card and a black screen.

Higher clock frequencies give you faster frame rates, faster processing times, and a snappier feeling. While adding RAM sticks to my soundcard for the sake of it doesn't make an impact, overclocking your CPU and GPU can make drastic improvements. And this month, we show you the latest tricks for how to overclock both. As for me, I'm using an Intel Skylake Core i7-6700K overclocked by an impressive 800MHz. And best of all, the upgrade was free!

Oh, and in case there's any doubt, the "Turbo" button on older PCs actually underclocks the CPU if not pressed.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Console Goes 4K With Pro Release

PS4 hardware upgrade plays catch-up with PC

NEXT MONTH, Sony takes its PS4 into 4K gaming with the release of the PS4 Pro. This is a departure from the usual route taken by consoles, because it's a significant hardware upgrade without being a next-generation machine, or requiring a new library of games. The PS4 Pro runs all PS4 games, and there are no exclusives. It will set you back $399—a hundred bucks over the standard PS4, which will be sold alongside as the new PS4 Slim.

The PS4 Pro has more powerful silicon: the AMD Jaguar CPU runs at 2.1GHz rather than 1.6GHz, and there are 36 rather than 18 compute units to the AMD RX 480 GPU. It has roughly twice the graphical grunt of a PS4—about 1.84 teraflops. The headline abilities are 4K and HDR graphics, and potential as a VR machine.

The PS4 Pro aims to keep PlayStation 4 hardware still in the game as PCs get ever more powerful.

Why release new hardware mid-generation? Because consoles are struggling against gaming PCs. The original PS4 had the technical specifications of a decent entry-level gaming PC, but PCs have since pulled ahead significantly. Microsoft has had to do the same hardware bump with the Xbox One S. Even with these upgrades, consoles are still being trounced by high-end PCs.

> Even with these upgrades, consoles are still being trounced by high-end PCs.

Not quite 4K

We were promised 1080p games on the original PS4, but it transpired few could manage that at smooth frame rates. Full native 4K, that's 3840x2160, is a tall order for console gaming. PCs have been capable for a while, but you still need to pack decent hardware to enjoy a high frame rate. The only PS4 game that is capable at the moment is *Elder Scrolls Online*, which can manage 30fps. Everything else, for now at least, uses upscaling in one form or another.

So, is the PS4 Pro a true 4K gaming box? It's technically capable, but the practicalities mean it'll see limited use. You will get excellent 1080p or 1440p at 60fps. Throw in temporal and spatial antialiasing algorithms to upscale for a 4K display, and the results will be close enough that the naked eye will have a hard time telling the difference from the couch. But for full-on 4K, it doesn't really have the horsepower.

Perhaps the most significant part of the PS4 Pro is the backward compatibility. Throwing away your game collection after every hardware upgrade was always a painful part of console ownership. Microsoft added limited backward compatibility into the Xbox One, but the PS4 Pro goes one better.

The PS4 Pro won't be the most powerful console for long; Microsoft's next-generation Xbox, Project Scorpio, is due next summer. This reportedly has six teraflops of graphical processing performance, which should be enough to offer native 4K, though we reserve judgement until we see it. It'll also run Xbox One games. It will be significantly more expensive than the PS4 Pro, though. But even this still lags behind a decent gaming rig. If there ever was a war between consoles and PCs over gaming's higher ground, the PC won a while back. **–CL**

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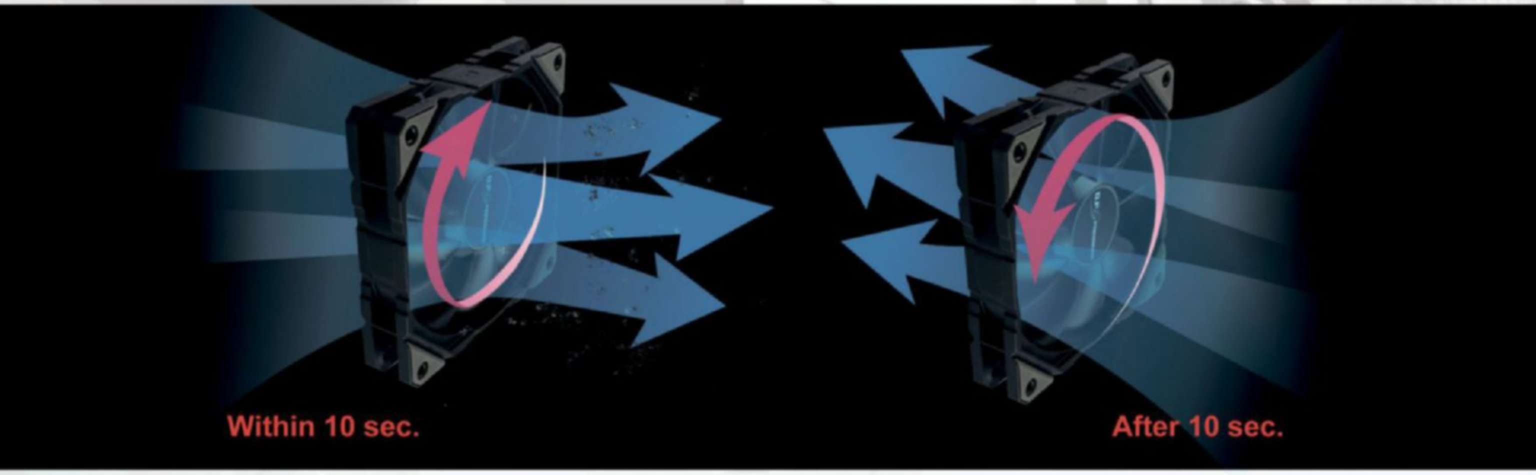
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iPHONE 7 DROPS HEADPHONE JACK

Apple simultaneously delights and annoys

APPLE'S NEW iPHONE 7 is here, and along with a fancy new camera and other upgrades that make it so desirable, Apple has decided that you don't need a 3.5mm headphone jack anymore. Instead, you'll plug the bundled headphones into the Lightning port. There's a clunky-looking adapter if you insist on using old-school kit. Apple has also launched its wireless headphones, called AirPods, which is what the hipsters will want. They're $159 a pop, so don't drop them. Or lose them.

Apple's marketing chief said, jokingly, we trust: "Some people have asked us why we would remove the analog headphone jack. It's been with us a really long time, and it comes down to one word: courage. Our team has tremendous courage." More seriously, it does make more room available inside, and make it easier to make the phone water-resistant. Online reaction has been mixed; at times, vitriolic. As ever, Apple will no doubt ride the storm. The company has an enviable record of hitting the zeitgeist before people realize it was the zeitgeist. It dropped USB on the iPad, and we learned to live with that.

Meanwhile, the European Union has decided that Apple received unfair tax concessions from Ireland, where its European HQ has been operating virtually tax-free for years. It wants $14.5 billion back. If Apple pays, it can claim it back as a foreign tax credit. The Irish government has appealed the ruling as well. Either way, Apple can afford it, and can probably avoid it. Once again, Apple impresses with its acumen and flair, and annoys us by what it gets away with. **–CL**

A NEW FORM OF DESKTOP

SURFACE AIO IS COMING

MICROSOFT IS REPORTEDLY working on three final designs of its Surface AIO (all-in-one) machines, and is gearing up for a full product launch, probably some time in 2017. The Surface AIO is a reworking of the traditional PC, bringing together tablet, PC, and more into one unit, with the aim of bringing a natural and instinctive level of control and connectivity.

The Surface AIO will be based around a large, high-res screen; 21-inch, 24-inch, and full 4K 27-inch designs are being tested. The key bit of tech is PixelSense. This enables it to identify objects placed on the screen. You can paint using a real brush directly on the surface, for example. Pop on your phone, and it launches the appropriate apps.

Microsoft has been working on the concept for many years—it built 85 prototypes before even showing off the concept design in 2005. Even so, actual details are thin on the ground, but from the level of buzz, it is going to be one to watch. **–CL**

LENOVO'S VIRTUAL KEYBOARD

Say "goodbye" to physical keys

LENOVO'S NEW YOGA BOOK laptop has ditched the keyboard for a multi-function touch panel, which will also appear on forthcoming Chromebooks. The hybrid tablet has a traditional clamshell design, one half a touchscreen, the other the new touch panel, christened the Create Pad by Lenovo. The "watchband" hinge enables you to fold it either way.

The back-lit virtual keyboard has 2,048 levels of pressure sensitivity, and doubles as a graphics tablet. Using a stylus, you can write or draw straight into compatible apps. You can even pop a sheet of paper over it and draw or write on that. OCR would be useful, but isn't included as yet. Marrying keyboards and touchscreens has often been clumsy, but this is a simple idea that could work well in practice—expect to see more of this type of design. The Yoga Books start at $499, and run Windows or a customized version of Android. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

LOTS OF PI
The tiny Raspberry Pi has clocked up 10 million sales since 2012. It looks likely to become the best-selling computer of all time. It costs from $5 to $120.

WALKMAN GOES HI-FI
Sony has moved the Walkman further up-market with the silver NW-WM1A costing $1,200, and an oxygen-free copper NW-WM1Z at a cool $3,200.

BEST GAMING LAPTOP EVER
Acer's Predator 21X laptop is the first to spot a curved display, all 21 inches of it. It also has two Nvidia GTX 1080s.

TRAGEDIES

PHONE FIRES
A battery fault in Samsung's Galaxy Note 7 meant there was a chance it would catch fire when charging.

FAULTY RESEARCH
704 academic papers on gene research contained errors caused by Excel converting cell contents, typically gene names to dates.

BROKEN WINDOWS
Win 10's Anniversary Update killed a lot of people's webcams—it dropped support for anything other than uncompressed YUY2.

Jarred Walton

TECH TALK

The Changing State of Multi-GPU

IF YOU'RE RUNNING MULTIPLE GRAPHICS CARDS in your gaming PC, some developments over the past year have upset the status quo. Windows 10 was supposed to bring us to the promised land of DirectX 12, but it's increasingly feeling like a wilderness dotted by an occasional oasis, rather than a land flowing with milk and honey.

There are three possible multi-adapter modes in DX12. Implicit Multi-Adapter (IMA) is similar to DX11 doing multi-adapter, where the game has no real knowledge of the GPU count; no games have implemented this mode at present. Explicit Multi-Adapter (EMA) comes in two flavors: linked and unlinked. The GPUs must be identical with linked mode, while unlinked mode allows heterogeneous GPUs—including teaming up AMD and Nvidia GPUs.

The total count for DX12 games is currently 10, with half a dozen or so planned. Of those 10, only two implement DX12's multi-adapter support: *Ashes of the Singularity*, with EMA unlinked support, and *Rise of the Tomb Raider*, with EMA linked mode. There's nothing Nvidia or AMD can do via drivers to change this—it's up to game developers to include support for multiple GPUs with DX12 (or Vulkan). Microsoft recently released a new library (http://bit.ly/2czx3uy) to help developers implement multi-GPU support with "minimal changes" required to the game code, so things may improve.

Nvidia's Pascal architecture further muddies the waters, putting the kibosh on three-way and four-way SLI. The company now recommends against running more than two GPUs in SLI mode on Pascal, partly because it's ditched its old SLI ribbon cables in favor of a new high-bandwidth (HB) rigid SLI bridge that uses both SLI ports. Another change is that only the 1070 and above support SLI—1060 cards have no SLI connectors.

Pascal modifies Nvidia's SLI to support a new HB connector for improved two-way SLI capability.

> Nvidia's Pascal muddies the waters, putting the kibosh on three-way and four-way SLI.

The new HB SLI bridge increases the speed of the link from 400MHz to 650MHz, more than doubling potential throughput. You can still use the old ribbon cables with Pascal, but your SLI experience may not be optimal, particularly at higher resolutions. This is actually good news in many ways, as three-way and four-way SLI scaling has always been a bit of a crapshoot, with the added overhead of managing multiple GPUs in some cases actually reducing performance.

I've tested the various SLI modes with dual GTX 1070 cards, and the HB SLI bridge does indeed improve performance—how much depends on the game and resolution. Compared to two SLI ribbon cables, the HB SLI bridge is only 0–5 percent faster, but against a single SLI ribbon, some games improve by 20–40 percent, particularly at 4K.

But two-way SLI isn't the only option. Going back to DX12, developers could, in theory, use EMA to support as many GPUs as they want—they can even use discrete graphics for heavy lifting and integrated graphics for lighter work. But that's only theory. Of the two games to implement DX12 multi-adapter, neither uses more than two graphics chips, and in the case of *Ashes'* heterogeneous support, the two cards have to be similar in performance. We're still waiting to see if other developers can come up with superior DX12 multi-adapter support.

AMD is championing its DX12, as its GCN architecture often does better than under DX11. AMD also doesn't use CrossFire bridges any longer, instead sending all the data over the PCIe bus. But the RX 480 falls behind the GTX 1060 in most games, and AMD recommends two cards as a less expensive alternative to Nvidia's faster GTX 1070/1080. It's a bit of a mess, which will hopefully get sorted next year.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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OPEN SOURCE

What We Should Expect From Electronic Voting

IT IS SAID THAT THE UNITED STATES has a revolution every four years, when we cast our votes to elect new people to represent us in our government. (It's really every two years, because mid-terms matter, too.) While the system has its flaws, most would agree that voting is an important part of having a say in how our government functions.

How we vote is one of the strongest signals that the citizenry can send. That's why protecting the vote is so important.

I've said before that public institutions should turn to open-source software, such as desktop Ubuntu and LibreOffice for workstations. My reasoning is that the software would cost governments—from the local to the federal level—close to nothing. Resources that could have been spent on licensing could be reallocated for auditing code, with the remainder dumped back into general funds.

When it comes to voting machines, however, the mere mention of electronic voting makes some people uneasy. Granted, there are already plenty of people who are worried about election fraud, but the introduction of electronic machines offers a new vector for affecting the outcome of elections. Due to this danger, I think it is clear that we cannot trust the software running on these machines simply because a company says we should.

If our counties decide to use electronic voting, we need to get one thing right: We have to make sure the code running on the machines is auditable and transparent to the public. By making the code available online in a Git repository, citizens, security professionals, and government agencies can make sure that the code is as air-tight as it can be. This kind of openness will also help inspire public confidence in the system. In an extreme situation, the results could be rejected by a populace, regardless of how legitimate the results are, if the process is perceived to be compromised.

> We cannot trust the software running on these machines simply because a company says we should.

CREATIVE COMMONS PHOTO: WIKIMEDIA COMMONS

Open-source software and better security measures could make electronic voting less vulnerable to tampering.

To maintain that public trust, government agencies such as the Federal Election Commission, non-profits like the Electronic Frontier Foundation, and security companies such as Symantec or Intel should team up to make sure the code is as secure as possible. Remember, open-source software isn't any more secure, unless somebody is actually auditing the code.

None of this should make voting machine companies worried, if they are legitimately looking to provide a reliable product to governments. The local counties and cities would still have to buy the machines, and pay to have techs maintain them.

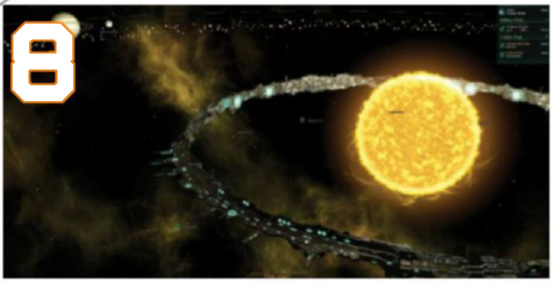
Electronic voting could further be secured by having a system of public and private keys that are distributed in official mailers, like sample or absentee ballots. Each mailer could contain a unique key in the form of a QR code that could be read by a machine, which would authenticate the voter. A key could never be used twice. If a provisional ballot/key was cast, the original key could be held in escrow until the voter could verify how they voted. Validation after voting could be sent via SMS, requiring the voter to send an affirmative reply for the vote to be finalized. These are just a few ideas that aren't without their own challenges and flaws.

There are several ways to attack the problems of electronic voting, but the transparent nature of the software running the system remains as the keystone in keeping the public trust. If we can't do that, we probably should just keep using paper ballots. Those tend to work fairly well, too.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

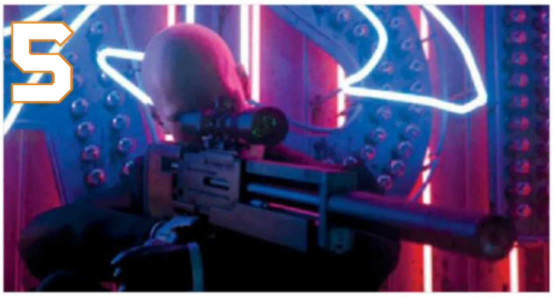
THE BEST GAMES OF 2016



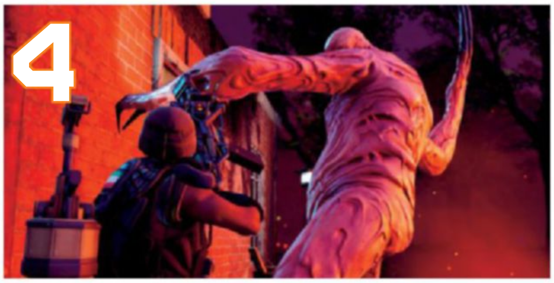
STELLARIS It may not be perfect, but this 4X space strategy game has consumed a lot of our time.

FAR CRY PRIMAL The series goes back to the stone age for more visceral thrills and spills.

OVERWATCH A fun, fast-paced team shooter that puts strategy above individual skill. Beautifully polished.



HITMAN The episodic release model is a little odd, but there's plenty of entertainment to be had here.



XCOM 2 Tough decisions make progress feel well earned. Definitely not for the faint-hearted.

TOTAL WAR: WARHAMMER A perfect marriage of meticulously detailed war with elves and vampires.

RISE OF THE TOMB RAIDER Lara's back with a vengeance, in a sumptuous-looking sequel to the reboot.

WORLD OF WARCRAFT: LEGION Blizzard still knows how to make the best MMO in the world.

Windows 10

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TALKING

BY **ZAK STOREY**

Nvidia Talks About the Realities of Pascal

Maximum PC gets under the hood of Nvidia's latest GPU architecture

Nvidia's success with Pascal stems from its ability to push the limits of the upper echelons of PC gaming. The GTX 1080 currently decimates the field in terms of frame rate performance. So, we sat down to chat with Justin Walker, senior product manager at Nvidia, to get the low-down on just what makes the Pascal architecture so special.

Working with Nvidia for over 11 years, senior product manager Justin Walker is a kingpin of knowledge when it comes to Team Green GPUs.

Maximum PC: Pascal seems to have been quite a revolutionary step for Nvidia. How do you go about developing an architecture like that?

Justin Walker: That's kind of a big question, but Pascal was probably one of the biggest—if not the biggest—undertakings this company has ever done. We invested billions of dollars into it, it was a pretty ambitious project, and it's a little hard to sum up the scope and the extent of it in just a few minutes. But, from a high level, it's about our architectural team taking a look at areas where we can improve our architecture, taking a look at the process technologies that are coming out, evaluating the technologies, evaluating how well they're going to work with our architecture, and looking at areas and forward trends where we think the graphics industry is headed. We obviously spend a lot of time with developers and the folks making games, and seeing the types of techniques they're using, and the types of displays being used, things like that, and incorporating all of those ideas into creating an architecture. It's a pretty broad scope.

MPC: We're finally starting to see GPU clock speeds well over the 2,000MHz mark—what's made this kind of speed and this level of performance possible?

JW: It's a combination of things. If you look at the clock speed improvement between Maxwell and Pascal, you could attribute roughly half of it to the new process technology, and about half to the architectural engineering work. The process technology is great, you see a good speed-up from that. In addition to that, it's about selecting the correct transistors to put in the correct areas, then a whole bunch of engineering work to determine the timings of all the paths within the chip. So, it's a combination of a very nice processing technology with a ton of engineering work that goes into analyzing the speeds and where your bottlenecks are, and adapting and changing around the layouts and the architecture to eliminate the slowest paths. The chip can only go as fast as the slowest path, so our engineering team spends a lot of time analyzing that and eliminating those paths, so the whole thing can run a lot faster.

MPC: Simultaneous Multi-Projection (SMP) is something Nvidia seems to be placing a lot of weight on—can you give us a brief summary of exactly how this works and what it does?

JW: From a high level, SMP is a recognition that a lot of displays that are being plugged into our GPUs are no longer just squares. The traditional way of rendering is you render a 3D geometry, and project it through a square. With SMP, we're able to not just do a single square, but project into multiple planes, and rotate those planes. You can take those planes and kinda rotate and adapt them to more closely fit the display that you're trying to render to. So, where that makes a big difference is gaming, where you can take a scene and project it on the center plane, then you can rotate it to the correct angle for the two edge planes. In the past, when doing surround, we're actually just taking one big long rectangle and projecting it on to the screen, and when you rotate those screens on the wings, the viewport, you know the view that you're seeing doesn't actually change, so you end up seeing it wrong. But with SMP, we can rotate those projection planes along the edges to correct it and make it look accurate, and we can do that without a performance penalty, because the architecture can reproduce those planes simultaneously.

Another big application of it is virtual reality, where the screen is flat, but you need to warp the projection to compensate for the lens within the VR headset. When rendering to a square and then warping it, you end up wasting a lot of pixels around the periphery, because you're rendering too richly around the perimeter, and not enough in the middle. So, with SMP, we can manipulate those projection planes to more closely match the shape of the lens.

MPC: Looking at the GTX 1060 in particular, what prompted the decision to stick with a 192-bit bus and 6GB of GDDR5?

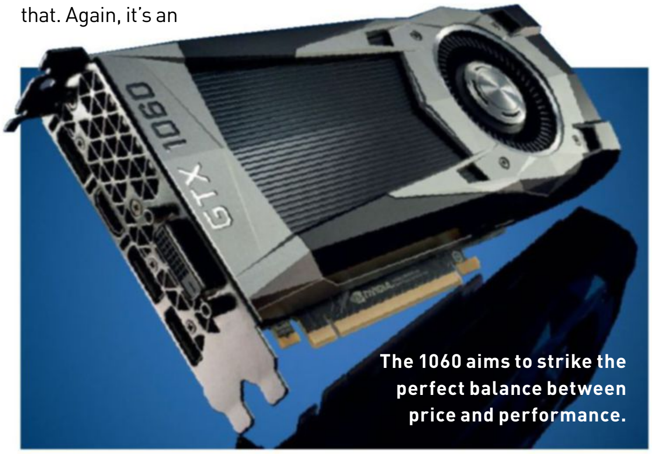
JW: Well, the 1060 is about balancing price and performance. It was the optimal configuration where we could balance great performance with a really good price. We combine the 192-bit bus with higher-speed GDDR5—it's getting up to 8Gb/s now—and a fourth generation of color and memory compression technology. By using that, we're able to get a significant step up in effective bandwidth, even with the 192-bit bus. So those technologies allowed us to use the 192-bit bus, and achieve the cost effectiveness needed.

MPC: We're quite surprised that Nvidia didn't opt to go with HBM 2.0 on the Titan X. Can you give us a little insight into why?

JW: It's a similar answer to the 1060. With Titan X, we were able to achieve the memory bandwidth that we needed using the next generation of GDDR5—GDDR5X—which can get up to 10Gb/s of memory speed. We put that on a 384-bit bus, and combined that again with our compression technology, and we were able to achieve a significant step up in effective bandwidth. And because we added those technologies, and because we had access to the higher-speed memory and the color compression technology, we were able to achieve enough effective bandwidth to feed all the cores, and to feed the GPU with as much bandwidth as we needed, which was great, because we were able to do it with a technology that wasn't quite as exotic, which was more available, and easier to get.

MPC: Speaking of the Titan X, can you talk to us a little about who this card is aimed at?

JW: I guess the reason you've been hearing some mixed comments is because it actually is a mixed audience. Let me take a step back for a second. Now, Titan X, as Titan has kinda been in the past, is our ultimate GPU, right? And, as such, there are a lot of groups that are going to enjoy and take advantage of it. For certain, people doing deep-learning are loving Titan X—not only is it super-powerful to help with the network training, but with Pascal, we added support for an INT8 instruction set, which really helps with the inferencing side of things as well. It was also made for folk doing digital content creation—kinda smaller media business folk, using things like Adobe, or color correction, or things like that. Again, it's an artist, it's a content creator, who just has a PC under their desk, and they just need to run out to the store and grab something that's going to be able to help them create this content in a more time-effective way. And, finally, it's also the fastest gaming GPU around, so for those looking for the absolute best, the Titan X is it.



The 1060 aims to strike the perfect balance between price and performance.

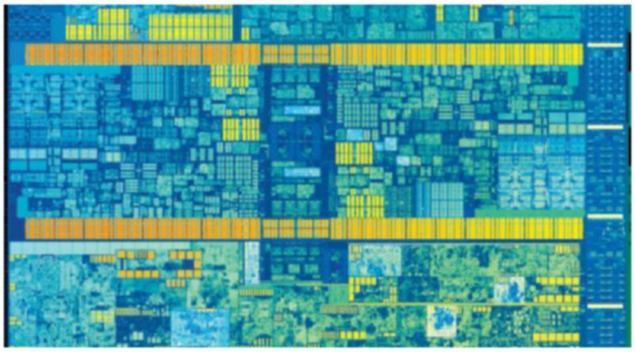
MPC: We have to ask: Why no SLI support on the GTX 1060?

JW: It's actually more straightforward than you might think. The idea behind SLI has always been to create the fastest gaming rigs around. The true value of SLI is when you've gone as far as you can with a single GPU, you can add another one to go even further, to build those super-high-end rigs. And that's really what most people use it for. If you look at who's using SLI and which GPUs are being put in SLI, the vast majority of those are high-end GPUs. And when you get down to something like a 1060—the 1060 was a GPU that was made to balance price and performance; it was made to kinda hit a sweet spot of price and performance—putting two of those in SLI doesn't make a whole lot of sense. In most cases, if you're going to spend that money, just go get a higher-end GPU, and in the end you're going to have a better gaming experience on that. So, it's because it's not really a recommended configuration. It's not something a lot of people are using, so we're going to go focus all of our efforts on making the high-end SLI experience as great as we can, which is why we've continued to invest heavily in game-ready drivers, and making sure that SLI runs great on our high-end configurations. ⏻

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> BIOS Bother
> Power Problems
> Missing RAID



Enthusiasts waiting for Intel's Kaby Lake on the desktop shouldn't hold their breath; this refresh is mobile-oriented.

Using the Right BIOS

Hey Doc! I have a PC I bought from Staples back in 2012 (I know, that might look a bit weird, seeing as this is an enthusiast's magazine). It is an Acer Aspire M3420-ES348, with 8GB of DDR3-800 RAM, an AMD A10-5700 APU, and Radeon HD 7350 graphics, all installed on an Acer AAHD3-VC motherboard.

My question involves updating its BIOS, as I think that's related to my performance issues (though I do realize the hardware is also very old). The current firmware version is P11-A4. I downloaded P12-B0, but I keep getting an error that says the ROMID is not compatible with my current ROMID, or something along those lines. Looking at the build, I think the B in the version is related to the incompatibility. However, that is all I could find for updates, as Acer discontinued this model shortly after I purchased it.

–Trevor Giampieri

THE DOCTOR RESPONDS: The BIOS you downloaded corresponds to Aspire M3420 PCs with Richland-based APUs inside, Trevor. Your A10-5700 is based on that design's predecessor, referred to by its code name, Trinity. Both were manufactured using a 32nm process and dropped into Socket FM2 interfaces. In fact, their CPU and graphics architectures are identical. But differences in how they handle power management may cause an incompatibility with your machine specifically. According to Acer's support site, version P11.B4, released on January 27, 2014, appears to be the newest intended to work with your configuration.

Don't worry too much about the BIOS, though. If the Doc were to guess, your performance issues are originating elsewhere. A low-cost SSD could breathe some life into the existing hardware. Or, consider upgrading the whole machine. You'd be amazed at how far a few hundred dollars can go when you pick well-balanced parts.

Uninterruptible Power

Dear Doc, I want to know about uninterruptible power supplies. I have one protecting my son's computer, which I purchased as a Christmas present for him, and it kicked in a couple of times since then. But now, every time we have a power outage (even extremely short ones, a second or two long), his computer shuts off. The UPS just doesn't seem to keep the power flowing anymore. Is this bad for his computer? How do I know what to choose as I get ready to shop for a replacement? **–Bruce K**

THE DOCTOR RESPONDS: There are many possible explanations for your son's UPS dropping its load and rebooting his PC.

First (and this is going to sound silly, since this UPS was working fine at one point), be absolutely sure the system is still plugged in to an outlet attached to the battery, and not one simply protected by surge suppression. Most units come equipped with both types.

Next, consider the possibility of a battery issue. Depending on the unit, there should be a way to gauge the power source's health or capacity. A battery that won't charge does no good in the event of outage. A reputable manufacturer will guarantee its product for at least a year, so if your son's UPS was a Christmas present in 2015, there's a good chance it may still be covered.

Less likely, but still worth checking off your list, is an overload condition. Depending on the battery backup unit's capacity, equipment plugged into it may try drawing more power than the UPS can deliver. This may result in it shutting down unexpectedly. Visit any number of UPS sizing calculators online to help determine the Volt-Amp (VA) rating most appropriate to your son's PC.

Heightened sensitivity to transfer times, ground

↘ submit your questions to: doctor@maximumpc.com loops, and proprietary communications cables can all cause the symptoms you're seeing as well, though they're more likely to crop up in business environments served by higher-end UPS systems. The Doc definitely suggests getting to the bottom of your flaky battery backup, though. It's bad enough to lose a school project when the power goes out, but it would be considerably worse to fry a PSU or motherboard, taking you completely out of commission.

Missing RAID Array

Doc, I thought I would give you a try. I am a long-time subscriber of *Maximum PC*, because it is hands-down the best mag for us experimenters.

My problem is that I recently upgraded my copy of Windows 10 with the Anniversary Update. It was at that point I lost the RAID with all of my games and productivity apps. The array is recognized in the BIOS, but when Windows boots up, it's nowhere to be found. Prior to the update, everything worked perfectly. I have tried everything and simply cannot get Windows to recognize the array. This includes reinstalling the operating system twice. The closest I have come to a diagnosis is the possibility that there's a bug in the update, preventing Windows from seeing hard drives in RAID.

Now, don't laugh but my machine is seven years old. It consists of an Asus Striker Extreme motherboard based on Nvidia's nForce 680i SLI chipset. Windows is installed on a Samsung 850 Pro SSD, I'm running a GeForce GTX 970 graphics card, I have 6GB of Corsair RAM, and I'm using a new EVGA 750W power supply. The missing array is made up of two Western Digital 160GB hard drives in RAID 0.

I hope you can shed some light on my issue. Thanks!

–LJ Talbot

Invest in a high-quality UPS, such as Tripp Lite's BC600SINE, equipped with ample capacity and a sine wave AC output.

THE DOCTOR RESPONDS: The Doc has some good news and some bad news. On one hand, you are not alone in fighting the Windows 10 Anniversary Update. Other folks with nForce-based motherboards using RAID report their arrays are dropping out as well. Unfortunately, none of the current advice solves this anomaly.

One option is to block Microsoft from pushing its Anniversary Update on to your machine by choosing the "Defer upgrades" setting in "Settings → Update & security → Windows Update → Advanced options." Of course, you'll have to roll the Anniversary Update back if it's installed (and you still can). Another option is to break the array and operate both drives in AHCI mode.

You can't count on Nvidia to fix this; its last driver update for the nForce 680i SLI was in 2011. Microsoft is hammering out some of the problems introduced by its update, though, and hopefully this bug makes the company's list.

Maintaining Balance

Hello there, Doctor. I'm a fairly recent subscriber to the magazine (about two years now) and I love everything about it. I was looking through the August issue—specifically, the review of Intel's Core i7-6950X—and two of the benchmark numbers caught my eye.

For both *Total War* and *Rise of the Tomb Raider* (DX12), there is a fairly significant bump in frame rate versus the Core i7-5960X. This is not exactly news to any of us; a new processor performs better—who would have suspected?

However, I then wondered whether my personal setup is holding back my GPU. I'm currently running a Core i7-2600K overclocked to 4.3GHz, and smoothly cruising through the vast majority of games at 1080p, 60fps-plus on my G1 Gaming 980 Ti. I'm very aware that at my current resolution and refresh rate, I'm not in a position to really benefit from higher maximum performance, but is my beloved Sandy Bridge-based baby hurting my minimums in more taxing titles?

Furthermore, I'm approaching the point where I think a good platform update would be worth the investment, with all the advancements in NVMe storage, DDR4, and incredible efficiency packed in Mini-ITX packages. Are any of the current-gen CPUs looking to become long-lasting gems like the i7-2600K? How about speculation about Zen and Kaby Lake? **–Chris Howard**

THE DOCTOR RESPONDS: The most apparent benefits of stepping up from Sandy Bridge to, say, Skylake are platform-oriented. DDR4 support facilitates greater memory bandwidth, DMI 3.0 enables faster transfers from the PCH to the CPU, the Z170 chipset offers PCIe 3.0 connectivity for high-performance SSDs, and you get native USB 3.0.

But the step up from one quad-core CPU to a more modern quad-core model won't have the absolute performance impact you might be seeking. To take advantage of applications better optimized for threading, a six-, eight-, or 10-core processor would be necessary, and pricing goes up rather quickly on those.

The good news for your wallet is that, while some games are able to utilize more than four cores effectively, as you increase resolution, the workload becomes more graphics-bound. A QHD display and GeForce GTX 1070 would arguably yield a better experience than the new CPU, motherboard, and memory you'd need to start over.

As far as upcoming hardware goes, we now know that Kaby Lake is primarily aimed at bettering Intel's position in the mobile world, and probably won't improve much over Skylake on the desktop. Zen is more of a wild card at this point; AMD is making some aggressive claims about it, but those are not new. Check out our feature on page 38 to see what we know about Zen so far.

Catching a Case

Hi Doc! I have an Antec Sonata Designer 500 chassis. It is on the older side, but it has an 80 PLUS 500W EarthWatts power supply inside. Is this enclosure sufficient for a new system build? I'd like to power and cool an Intel Skylake-based processor, and either a Radeon RX 470 or a GeForce GTX 1060 graphics card. **–Bill**

THE DOCTOR RESPONDS: The Sonata's suitability for your new build depends on the hardware you want to put inside. Fortunately, it's a mid-tower enclosure capable of accommodating ATX, microATX, and Mini-ITX motherboards, plus plenty of drive bays and I/O. The biggest issue you'll have with it is a lack of USB 3.0 connectivity up front. Both of the case's front ports are limited to second-generation transfer rates, unfortunately.

That EarthWatts EA-500, on the other hand, is well suited to a world worried about efficiency. The most power-hungry Skylake-based CPUs top out at 91W. A Radeon RX 470 is rated at 120W, so is the GeForce GTX 1060. Needless to say, a 500W power supply has plenty of headroom for the rest of your platform components.

For the best of both worlds, consider keeping the Antec power supply and splurging on a more modern case with the convenience of USB 3.0.

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OVERCLOCKING REMASTERED

An artisan's guide to breaking the hertz barrier. By *Zak Storey*

The two most important days in a system's life are the day it is born, and the day you push it to its full potential. Yeah, OK, that's a slight reworking of a famous Mark Twain quote, but it's inherently true. PCs are designed to be tested. It's that constant striving for more performance, higher clock speeds, and greater IPC from generation to generation that propels the computing industry forward under its own momentum.

Consumers want more. We want more. More performance, quicker load times, faster renders at higher qualities. That's what it's all about. And how do you get the most out of a processor? You overclock it. Yes, it does come with its caveats—power draw, in particular—but in our eyes, the positives far outweigh the negatives. And to those naysayers ready to pounce on eager overclockers with statements like, "Are you really going to gain much from 100 points in Cinebench?" or "It's just not worth the extra power," well, folks, we're here to tell you that's pure hogwash.

Why? Simply put, the benefits of CPU overclocking in the workplace environment are huge. Going from 4.0GHz to 4.8GHz on an Intel Core i7-6700K, for example, can shave off a sweet 20 percent when it comes to video render times, in contrast to running at stock. It doesn't sound like much, but if you consider an average 10-minute 4K video would take an hour to render, that's 12 minutes saved on a single run. Do that three times a week, four times a month, for a year, and all of a sudden you've saved more than a day working on your content. That's a pretty big deal in our eyes. To say overclocking is pointless is the equivalent of saying that pursuing advances in processing speed is pointless.

Of course, with GPU overclocking, that is centered entirely around the leisurely pursuit of gaming, and increasing those main frame rates—but that's something we'll touch on a little later. So, what do you need to know? What do you need to crank up that frequency? And what can you do to make your system more stable in the process? You'd better turn the page....

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crucial

What to Expect When Overclocking

YOU'VE SELECTED YOUR HARDWARE, you've chosen your overclocking-capable chip, now you need to do some research on your core and how well it's going to clock. On top of your processor, you'll notice a string of numbers—this is known as your chip's batch, and indicates which silicon wafer your chip is derived from. A quick Google search often provides forums where other enthusiasts are benchmarking cores from the same wafers, giving you a rough estimate of how yours will perform.

It's also worth doing some general research. Fortunately for the consumer, you have the advantage of reviews coming out ahead of time, indicating what you can expect in terms of overclocking potential. Getting a good grounding and idea of just how far your chip will go not only gives you suitable targets to aim for, but also a sensation of just how lucky you can be.

MOTHERBOARD SELECTION TIME

Your choice of motherboard is one of the factors that tends to vary the most when it comes to the overclocking experience, either through hardware choices, UEFI BIOS, or general stability. Everyone has a particular brand of motherboard they enjoy overclocking on. For us here at *Maximum PC*, it's Asus—the clean and crisp BIOS, coupled with a plethora of additional settings, means we have full access to a wide range of overclocking features that are sometimes ignored, locked, or often not included with other brands. That's not to say that you'll find the highest overclock records here, but generally speaking, for the everyday user, who only has access to one processor, you can usually get some seriously impressive performance out of an Asus-branded motherboard.

Outside of UEFI BIOS, overclocking profiles, and settings, motherboards control how the voltage reaches your processor. The eight-pin EPS power provides juice straight to the processor, which is converted via the voltage regulator modules (VRMs), by using a combination of pulse width modulators (PWMs) and metal oxide semiconductor field effect transistors (MOSFETS), from the 12V power down to 1.2V VID that the CPU needs to operate.

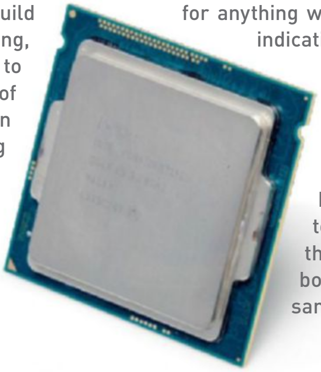
AUTOMATIC VS. MANUAL

What we're talking about here are automatic overclocking profiles and features. Asus has its AI Tuning, MSI its Game Boost technology, ASRock its preset profiles—you name it, if a motherboard manufacturer has a Z170 mobo, it's likely there's an accompanying, well trademarked form of automated overclocking.

In theory, these are great; an easy way of gaining a 10–20 percent increase on your clock speeds. That said, there are always going to be limitations, and these automatic features almost always apply more voltage than is strictly necessary. For instance, our auto Asus AI Tuning applies a Vcore of 1.34V, allowing us to get an overclock of 4.3GHz. In contrast, we can do the same overclock with a meager 1.31V on the Vcore, reducing overall temperatures by 10 C, while still retaining stability.

Requisite Hardware

TO THE INITIATED, you're well aware that you need specific hardware to make any overclocking ambitions a reality. You can't get away with a stock cooler and mediocre power supply in this day and age. In fact, there's more to it than that. From the outset, you need to plan your build ahead of time for overclocking, if it's something you want to pursue. There are degrees of preparation, of course. You can either opt to go the whole hog and purchase an AIO or a fully custom loop, or just purchase a K series processor and wait until a little later on in your rig's life cycle before taking the plunge into overclocking.



CPU

As an aside, you need a processor that's capable of overclocking, too, of course. Any of Intel's 2011 Extreme Edition processors are capable of overclocking, but for the more mainstream of us, you're looking for anything with a K after the name, indicating that the multiplier is unlocked.

This boils down to an Intel Core i5 or a Core i7, depending on your budget. Generally, Intel's i7 series tends to be clocked far higher than the i5 by default, but both often overclock to the same maximum.

CPU COOLER

Another essential item you need is a sufficient CPU cooler. The latest generation of overclockable Skylake and Broadwell-E processors come without a retail cooler. The theory being that if you're going down the overclocking route, you're going to be looking for something capable of expelling all that excess heat. As you add more volts to the core, the processor generates more heat. And in doing so, the processor is far more likely to hit its TJMax—or junction temperature maximum.

You can either choose a proper-sized full tower cooler from the likes of Noctua, Be Quiet!, or Cooler Master, or go for an AIO closed-loop cooler from Corsair, NZXT, EKWB, or any number of others.

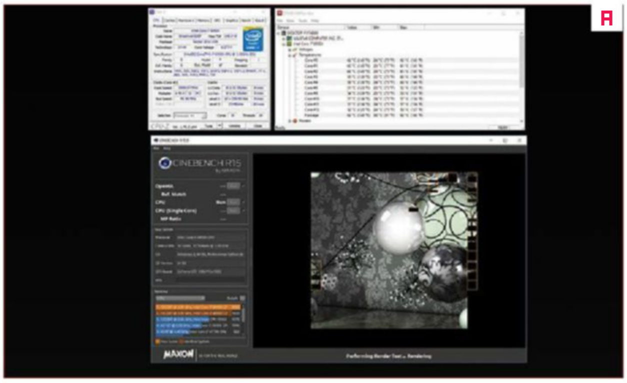
Overclock Your CPU

1 GRAB THE SOFTWARE

So, you've got your system set up and running at stock. Now it's time to crank up the volts and get that processor as high as it'll go. First thing you need to do is download a few programs. You're going to want to get something to provide you with a base number for performance—Cinebench R15 is quick, free, and a good indicator of rendering prowess. Next up, you need a synthetic benchmark—Prime95 or OCCT are two brilliant examples of this. OCCT, in particular, also stress tests memory channels at the same time. And lastly, you need two more programs—one to measure Vcore and one to measure temperature. We suggest CPU-Z for voltage and hertz monitoring, and HWMonitor for temperatures. Although HWMonitor also measures voltages, it's far easier to see what you're looking at with CPU-Z.

2 RUN PRELIMINARY TESTS

After downloading and installing your benchmarking software, you need to get some preliminary figures. It's best to note these down, or create a spreadsheet where you can document what voltage you're applying, to what multiplier, and what your scores, temperatures, and stabilities are on each attempt. This way, you won't forget, and can refer back to it later on. To begin with, open up CPU-Z and HWMonitor, then open Cinebench R15, and run the CPU test three times in conjunction [**Image A**]. Mark down all three of these scores, and take the average of them—this is your starting point. It's also best to note what your maximum core temperature is; ideally, you're looking for anything under 55–60 C. Finally, note the maximum voltage CPU-Z is registering during the benchmarks.



3 ENTER THE BIOS

Once you've got those early tests out the way, jump into the BIOS. We're using the Asus RoG STRIX X99 Gaming motherboard's BIOS. It's identical to the Z170 platform, as well as the other brands in Asus's arsenal, but with a black and red skin. Restart your system, and mash the Del key to get into the BIOS. Hit F7 to get into Advanced mode. Then head across to AI Tweaker.

4 YOUR INITIAL OVERCLOCK

Once you're in AI Tweaker, it's important to set up your memory so it's running at its optimal frequencies. Hit the "AI Overclock Tuner" tab, and select "XMP" from the drop-down menu. You'll want to start with an initial overclock [**Image B**]: Go to "CPU Core Ratio," and select "Sync All Cores." Input a slightly

MOTHERBOARD

Next on the list is your motherboard. Overclocking is more often than not locked to the higher-end chipsets—for Skylake that's Z170, and for HEDT, well, everything is overclockable. It's worth noting that the more expensive overclocking motherboards do help, because they generally tend to have better power phase designs, ensuring a more consistent voltage is provided to your processor.

CORSAIR
RM1000x

PSU

PSU choice is the easiest to mess up, and the worst to get wrong. The general rule of thumb is that you want around 20 percent leeway over what your system actually draws from the wall at peak load while overclocked. So, if an overclocked system draws 450W, you want a PSU that's rated for around 550–600W. On top of that, you want to spend at least $100 on it, and get a Gold rating or higher, purely from an efficiency standpoint. You can do it with a lower rating, but you will be drawing more power from the wall when overclocking, and the greater efficiency will save you money in the long run. Never skimp on this, because it can take most of the system down with it if it goes wrong.

WHAT WE'RE USING

In this feature, we're going with an Intel Core i7-6950X, an Asus X99 Strix Gaming motherboard, 32GB of Crucial Ballistix Elite DDR4 @ 2,666, a NZXT Kraken X61 AIO cooler, coupled with two Noctua NF-A14 iPPC fans on an open-air test bench.

If you plan on doing this at home, you need to ensure you have a suitable chassis with decent internal airflow. A positive air pressure system is advised, but balanced is just fine, and preferably do your overclocking somewhere cool, because ambient temperatures have a substantial impact on your overall overclock potential. Ideally, you ought to be practicing your overclocks at an ambient temperature of around 21 C or lower.

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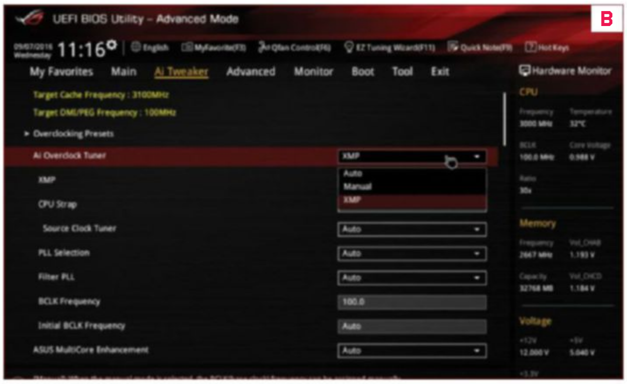
Overclock Your CPU, continued



Target Cache Frequency : 3100MHz
Target DMI/PEG Frequency : 100MHz
Overclocking Presets
Ai Overclock Tuner: XMP (Auto / Manual / XMP)
XMP
CPU Strap
Source Clock Tuner: Auto
PLL Selection: Auto
Filter PLL: Auto
BCLK Frequency: 100.0
Initial BCLK Frequency: Auto
ASUS MultiCore Enhancement: Auto

higher multiplier. So, if you have a Core i7-6700K reading "42," input "44." Hit F10, save, and reboot, then head to the desktop to see if it's stable. At this point, it's not worth messing with voltages.

5 THE STRESS TEST

Now repeat what you did with your preliminary tests. If the system is stable, great—you're on to a winner. Head back into the BIOS and increase the multiplier once more. You want to keep doing this process until the system locks up.

6 INCREASE THE VOLTAGE

Now you've hit the limits of the base voltage, you want to start increasing the voltage to the CPU to overcome those stability issues. This is where you start to see a substantial increase in overhead temperatures. Head back into the BIOS, to AI Tweaker, then scroll down until you see "CPU Core Voltage," and change it to "Manual Mode." Now, with your voltage noted down from earlier, change the "Voltage Override" from "Auto" to a setting slightly higher than that. We suggest increasing Vcore by 0.05 at a time at most—do this until the overclock holds through Cinebench R15. Then it's just a case of rinsing and repeating, slowly increasing the multiplier and Vcore side by side until the system is stable.

7 YOUR FINAL OVERCLOCK

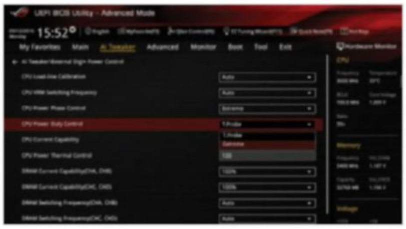
Eventually, you reach a point where both temperature and stability become an issue. If you've been noting down all these figures on a spreadsheet, this'll come in handy for the next bit. Ideally, you're looking for temperatures around 70–80 C under load. The reality is you'll probably hit silicon instability long before you reach TJMax. At this point, you want to dial it back down one setting to the last stable frequency [**Image C**]. After which, do a full system stress test by running a synthetic benchmark for anywhere from 1 to 24 hours, depending on your patience. We suggest OCCT here, because it also saturates the memory channels effectively. If you do run into any trouble, add a little extra voltage, or reduce the multiplier a fraction to compensate.

C
OCCT 4.4.2
Monitoring

Tips & Tricks to Push It Further

THERE ARE A FEW TRICKS to make your overclock go a little further. Head back into the BIOS, to AI Tweaker, then go to "External Digi+ Power Control." You'll find three settings we can adjust to improve overclocking performance for the latest Asus motherboards. First, disable "VRM Spread Spectrum." This stops the VRMs from attempting to reduce any electromagnetic interference by fluctuating the base clock of the processor. Nowadays, you shouldn't have a problem disabling it, unless you work with highly sensitive audio equipment. Next up is "CPU Power Phase Control"—change this from "Auto" to "Extreme." This ensures you use the full number of power phases on the board, meaning less stress on the MOSFETs, and more long-term stability. Down from that is "CPU Power Duty Control"—change this from "T Probe" to "Extreme." This stops the mobo balancing the power load based on VRM temperature, and instead focuses on splitting the current evenly across all the MOSFETs.

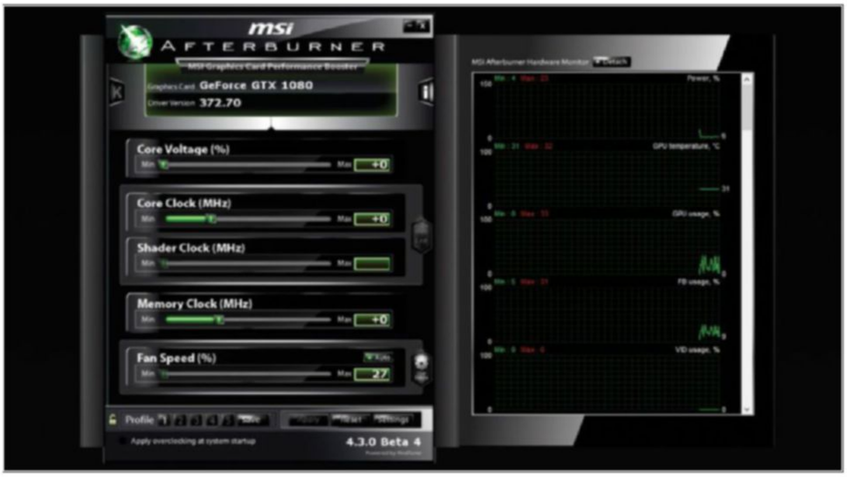
This last setting is well worth it. Intel processors have a particular piece of software called SpeedStep. What this does is fluctuate the multiplier and voltage going into the processor, depending on the load on the CPU. Most overclocks fail not as the processor is at 100 percent load, but as the multiplier and voltage increase up to the settings you've put in place while under load. Disabling SpeedStep ensures the processor is constantly running at the



frequency and voltage you set it. Don't panic, though—this doesn't mean you'll be running at 80 C constantly, because the CPU still abides by the laws of load, meaning although temperatures may be fractionally higher, the core won't get hot until under load as usual. Unfortunately, you will be drawing more juice from the wall, but that's part and parcel of overclocking anyway.

GPU Overclocking: Why Bother?

YOU'VE GOT THE PROCESSOR out the way, so what's next? Memory aside (we'll cover that later), it's all about the graphics card. For gamers, this piece of hardware is crucial when it comes to pumping out frames. Most graphics cards are capable of being overclocked—some are designed for it, others less so. Overclocking a GPU generally increases average frame rates, but, more importantly, minimum frame rates, too. So, you'll have a smoother experience, and in the heat of battle, screen tearing won't become another nemesis.



Graphics Card GeForce GTX 1080
Driver Version 372.70
Core Voltage (%) +0
Core Clock (MHz) +0
Shader Clock (MHz)
Memory Clock (MHz) +0
Fan Speed (%) 27

There are plenty of alternatives, but MSI's Afterburner is the best free solution.

BACK TO THE BLACKBOARD

Overclocking a GPU shares a lot of similarities with overclocking a CPU. Generally, you should always start at the same point: research. Know what your GPU is capable of, what architecture it's built from, and how well it overclocks. Unlike CPUs, GPU architectures vary wildly in overclocking potential.

We're using a reference Nvidia GeForce GTX 1080, with the Pascal architecture, which is very similar to the overclocking king, Maxwell, or the 900 series.

OC PROFILES AND PRE-BINNED CHIPS

Are OC profiles worth it? Well, similar to the automatic versus manual debate earlier, these profiles differ very little. Asus, MSI, Gigabyte, and EVGA set out a specific speed profile for each generation of card ahead of time, and bake it into some form of GPU overclocking software. This can work well, if you're lucky with the silicon lottery, but can fall flat if the processor doesn't hold well, and you end up with a card incapable of meeting its slightly overcompensating overclock profile. There's often no difference between a pre-overclocked GPU and a standard one—you're probably just applying a more aggressive overclock profile than you need.

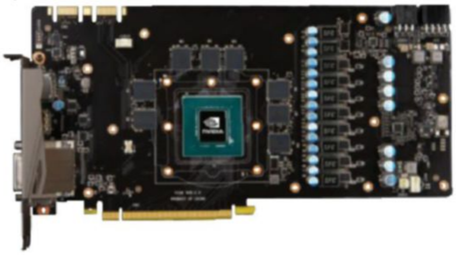
Then there's pre-binning. All chips are binned upon manufacture. Think of those silicon wafers: Each one houses an entire generation of processors, because location and variance within the silicon dictates which chip is what. The middle of the wafer is always better quality than the edge. And this is where the manufacturer discerns which processors will be 1080s, 1080 Tis, or Titans. These are sold to aftermarket partners. Now, these manufacturers can either just place them in the cards that they're assigned to, or bin them further. To do this, they test which cores leak the most voltage, which chips require the least volts to operate, and which chips overclock the highest. The very best go into the high end "premium" cards, such as EVGA's FTW cards, while the lesser ones go into more mid-range and reference cards.

COOLING AND AIB PCB

You also need to consider what style of card you want as regards cooling. There are four styles. The standard blower design features a single intake fan, drawing air into an enclosed shroud, pushing it through a heatsink, and out the back of the rear I/O—brilliant for cases with limited space. Then there are the dual or triple fan dissipation cards. These are often found on the heavy hitters—Asus's DCU III, Gigabyte's Windforce, and MSI's Twin Frozr are good examples. These cards draw air in and around via the main fans, push it down through a heatsink, and out into the surrounding case, and are often quieter and cooler than their blower counterparts.

Lastly, you get the fully water-cooled cards. These either come as a closed-loop card, such as the Fury X, or with preinstalled water blocks, such as the EVGA Hydro Copper, requiring you to insert them into a custom water-cooled loop. And on top of all that, there are the miscellaneous hybrids, often utilizing a combination of both air and water cooling.

There are aftermarket cards touting more advanced PCB solutions, too. These often include more advanced MOSFETs and chokes, in combination with a better power phase design, meaning better overclocks and higher performance as standard.



Overclock Your GPU

1 MORE PROGRAMS

Similar to CPU benchmarking, you need to download some software to get this baby started. Firstly, download GPU-Z—this program tells you exactly what GPU you have, and all of its stats, and also monitors maximum boost clock, memory frequency, and temperatures. You also need a quick synthetic benchmark, such as Furmark, to synthesize load, a more in-depth 3D benchmark, such as Fire Strike [**Image A**], an in-game benchmark (that's *Far Cry Primal* for us), and a program to overclock with. For Nvidia cards, we suggest using MSI Afterburner; for AMD, either use the integrated Wattman overclocking utility in Crimson, or Sapphire's TriXX software, depending on what you have available for your card. In this instance, we're overclocking the Nvidia GTX 1080, but the principles apply across both brands.

2 MORE PRELIMINARY TESTS

We want to benchmark the card at stock, and note down how the card performs in a spreadsheet. So, open GPU-Z, click the "Sensors" tab, click the drop-down arrow on "GPU Core Clock," and select "Show highest reading." Do the same for "GPU Memory Clock." Now open Fire Strike and run the standard benchmark at least twice. Note what GPU-Z states for the highest Core and Memory Clock frequencies [**Image B**]. This is how far GPU boost is pushing your core at stock. Note the average Fire Strike score, then run your in-game benchmark and take note of that as well. You can also write down the temperatures here (check GPU-Z), but you'll run into silicon limits long before thermal ones.

3 RAMP IT UP

Open up MSI Afterburner and increase "Power Target" to the maximum. Don't worry about it increasing "GPU Temp Target," as it's still well within operating parameters. Next, start increasing "GPU Clock Offset." To begin, increase it by 50MHz, and hit "Apply." Open up Furmark, and set it to a resolution appropriate to your card (we're looking to emulate 100 percent load without stuttering). For our GTX 1080, that's 2560x1440 at an AA setting of x4. Run "GPU Stress Test" and see if Furmark or the screen locks up. If it's still stable after three minutes, increase the clock offset by another 50MHz. Keep doing this, making notes, till you lock up.

4 CIRCUMVENT VOLTAGE ISSUES

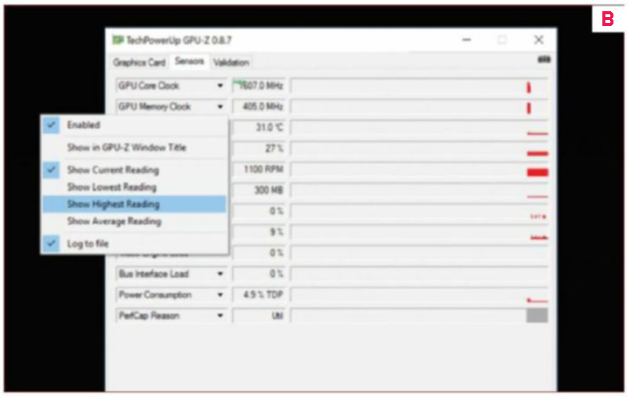
Now you need to overvolt the card to pump the core clock higher. In MSI Afterburner, go to "Settings," check "Unlock voltage control" in the first tab, then change the drop-down to your

CPU Benchmarks

	Intel Core i7-6950X Stock	Intel Core i7-6950X Overclocked	Intel Core i7-6950X Undervolted
TechARP x264 v5.0.1 (fps)	38.62	46.82	38.58
Cinebench R15 Single Core (Index)	145	142	130
Cinebench R15 (Index)	1,839	2,186	1,833
3DMark Fire Strike Ultra (Index)	5,190	5,232	5,228
Total War: Attila @ 1080p (fps)	41/57	48/59	43/58
Rise of the Tomb Raider @ 1440p (fps)	16/44	16/44	21/44
Synthetic Power Draw @ Load (Watts)	245	324	185
Temperature @ Load (Degrees Celsius)	61	82	46
Core Frequency and Vcore	3.5GHz @ 1.11V	4.3GHz @ 1.31V	3.5GHz @ 1.01V

Our testbed consists of an Asus X99 Strix Gaming, Nvidia GeForce GTX 1080, 32GB Crucial Ballistix Elite @ 2,666MT/s, 500GB Samsung 850 Evo, 1TB Samsung 850 Pro, Be Quiet! Dark Power Pro Platinum 1,200W PSU, and an NZXT Kraken X61, plus 2x 140mm Noctua NF-F12 iPPC fans.

For our full system overclocked, we cranked the Core i7-6950X up to 4.3GHz at 1.31V, and increased the core clock by 200MHz and the memory by 450MHz on the GeForce GTX 1080.



GPU Core Clock 1607.0 MHz
GPU Memory Clock 405.0 MHz
31.0 °C
27 %
1100 RPM
300 MB
0 %
9 %
0 %
Bus Interface Load 0 %
Power Consumption 4.5 % TDP
PerfCap Reason Util

type of card. Go back to the main interface, add 10mV/10 percent extra on the overvolt section, and try your overclock again. If this doesn't work, keep adding voltage until you get to around +40 percent—anything higher and you'll probably see stability issues. After that, it's a case of finding the sweet spot for the core clock. Increase or decrease by 10MHz until you find the GPU's limits.

5 CHECK FOR GRAPHICAL ANOMALIES

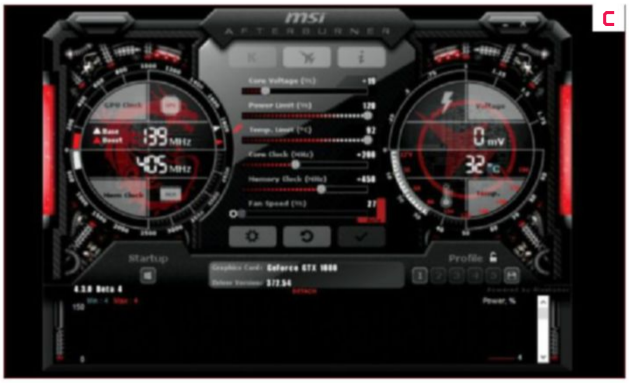
Now we have a stable overclock with Furmark, see how it holds up in a more intensive benchmark. Open Fire Strike, and run a single instance. You need to watch this. In particular, you're looking for anything that shouldn't be there: graphical anomalies, such as flickers, green or purple particles, anything that isn't in the original. To save time, go to the custom settings, and run Scene 2 or Scene 4, as they're the most graphically intense.

6 ALL ABOUT THAT MEMORY

To complete your overclock, improve the VRAM. To do this, go back into MSI Afterburner [**Image C**], and slowly increase the memory clock, again by 50MHz at a time. Generally, VRAM tends to be predictable about how high you can clock it: GDDR5 and 5X averages an increase of 400–500MHz, while HBM usually manages about 50MHz before it starts to fall over. Once this is done, and Furmark is still responsive, go back into Fire Strike and look for anomalies again. Fortunately, memory overclocks tend to be more aggressive in how those anomalies appear. If you're having trouble, drop down the memory clock by 10MHz each time, until you manage to get it stable. If you're still having trouble, and you've dropped down by 200MHz or more, try going back up, but reduce the overclock on the core by 10MHz at a time instead.

7 TRIAL AND ERROR

GPU overclocking is always trial and error. Because there are two different components to overclock, it can take time, but once you've got a stable profile dialed in, you're good to go. Save the profile in MSI Afterburner, note it down in your spreadsheet, and crack open GPU-Z once more. Set the sensors we changed earlier back to the highest reading. Run Fire Strike two or three times, plus your in-game benchmark, and you should see a marked improvement over your stock settings.



Core Voltage (%) +19
Power Limit (%) 120
Temp. Limit (°C) 92
Core Clock (MHz) +200
Memory Clock (MHz) +450
Fan Speed (%) 27
Graphics Card: GeForce GTX 1080
Driver Version: 372.54

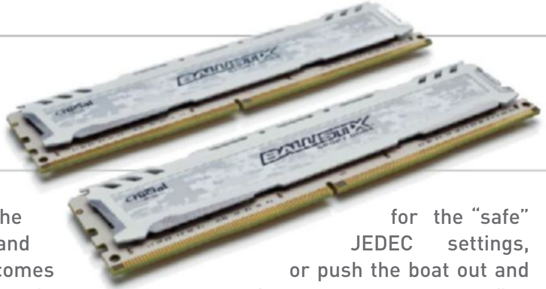
GPU Benchmarks

	Nvidia GTX 1080 Stock	Nvidia GTX 1080 Core OC Only	Nvidia GTX 1080 Core and Memory OC
3DMark Fire Strike (Index)	17,313	18,978	19,348
Far Cry Primal @ 1080p (fps)	58/94	72/108	71/111
3DMark Fire Strike Extreme (Index)	9,563	10,356	10,870
Far Cry Primal @ 1440p (fps)	58/77	67/80	65/84
Time Spy DX12 (Index)	7,205	7,707	7,970
Final GPU Boost Clock (MHz)	1,873	2,126	2,088
Final Memory Clock (MHz)	5,005	5,005	5,508
Temperature @ Load (Degrees Celsius)	77	86	85
Gaming Power Draw @ Load (Watts)	313	337	336

Our testbed consists of an Asus X99 Strix Gaming, Nvidia GeForce GTX 1080, 32GB Crucial Ballistix Elite @ 2,666MT/s, 500GB Samsung 850 Evo, 1TB Samsung 850 Pro, Be Quiet! Dark Power Pro Platinum 1,200W PSU, and an NZXT Kraken X61, plus 2x 140mm Noctua NF-F12 iPPC fans.

For our full system overclocked, we cranked the Core i7-6950X up to 4.3GHz at 1.31V, and increased the core clock by 200MHz and the memory by 450MHz on the GeForce GTX 1080.

Overclocking Your RAM



MODERN CPUS have plenty of memory bandwidth, so it's rare that your CPU will be starved on this front. But, even so, you can overclock your memory if you want. As the two are linked, doing so may mean you have to ease back on your CPU clocks, but for a memory-centric task, it may be worth it.

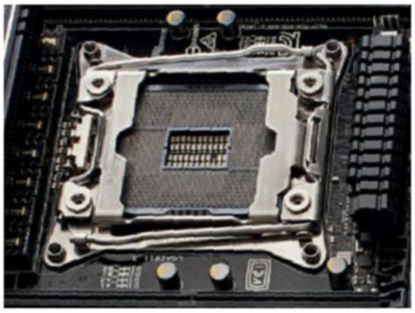
To overclock your RAM, you need to pop into your UEFI BIOS utility, and select the "DRAM Frequency"—base it on the memory's recommended specs, and increase gradually until it becomes unstable. You need to get the latency right, too, because a higher frequency with poor latency yields worse overall performance.

For most normal use, though, you'll just want to run your memory at the stock frequencies. Here, you can either go for the "safe" JEDEC settings, or push the boat out and go for a supported XMP profile.

If you experience any problems with memory (Windows will throw up a memory error), pop into your BIOS and go for a safe stock frequency setting. You'll barely see a difference in the real world either way.

Is Overclocking Worth It?

IT'S A TOUGH QUESTION to answer, and depends on your circumstances. Without doubt, overclocking is extra performance for free. It's an interesting pastime for those looking to broaden their custom PC building knowledge, and nowadays it's quite safe, too. There's always going to be drawbacks, though: The additional power draw is something we can't ignore, and heat dissipation does need to be addressed. That said, in our opinion, pushing hardware to the limit is why we're here, and what we enjoy doing most. For the average PC user, it isn't something to venture into lightly, but if it's available, why not take advantage of it?



That said, the computing world doesn't always revolve around more power and more performance. If you're looking at reducing the overhead temperatures and noise inside your case, undervolting may also be a solution. Intel has always been extremely conservative with the base VID that it applies to its processors upon leaving the manufacturing houses, and for many a chip, they're far higher than what's actually necessary to keep it stable—depending, of course, on your luck in the silicon lottery. Just take a look at our benchmarks on page 34, and you can see that by reducing our core voltage by just 0.1V, we managed to decrease our average temperature by 15 C, while still retaining a perfectly stable overclock, with minimal impact on performance.

All in all, if you have a K or X series chip, and you're not messing around with the voltages and frequencies, you're genuinely missing out. The world of overclocking can be fraught with thrills and frustration, but that feeling you get when you have finally dialed in the maximum for your processor is second to none.

Full System Benchmarks

	STOCK SYSTEM	OVERCLOCKED CPU & GPU
Cinebench R15 – Multi Core (Index)	1,839	2,199 (20%)
3DMark Fire Strike Extreme (Index)	9,563	11,006 (15%)
Total War: Attila @ 1440p (fps)	40	45 (13%)
Rise of the Tomb Raider @ 1440p (fps)	44	48 (9%)
Gaming Power Draw @ Load (Watts)	313	373 (19%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our testbed consists of an Asus X99 Strix Gaming, Nvidia GeForce GTX 1080, 32GB Crucial Ballistix Elite @ 2,666MT/s, 500GB Samsung 850 Evo, 1TB Samsung 850 Pro, Be Quiet! Dark Power Pro Platinum 1,200W PSU, and an NZXT Kraken X61, plus 2x 140mm Noctua NF-F12 iPPC fans.

For our full system overclocked, we cranked the Core i7-6950X up to 4.3GHz at 1.31V, and increased the core clock by 200MHz and the memory by 450MHz on the GeForce GTX 1080.

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ZEN

A NEW HOPE

Like a ragtag band of intergalactic rebels, AMD is back with a totally new CPU architecture to take on the Intel empire. Get ready for Zen, says *Jeremy Laird*

THIS IS AMD'S LAST CHANCE. We're not talking about the kind of empty peril you get in part one of a movie trilogy, where you know the main protagonists can't possibly die this soon. We're talking an actual existential threat to AMD's existence.

By "this" we mean Zen, AMD's all-new CPU architecture. After the better part of a decade unable to compete with Intel on performance, all the signs are that AMD has finally nailed it with Zen. Due out in early 2017, Zen will replace AMD's Bulldozer family of CPUs in desktops, laptops, and servers. It's a proper performance CPU, not some puny apology of a chip designed to go into toasters, or whatever else Internet-of-things aficionados have in store for us. In other words, it's a chip that PC enthusiasts can get excited about. And yet its provenance is mixed, to say the least.

AMD's existing Bulldozer CPUs are the problem. They arrived late, were hopelessly off the pace at launch, and never came close to catching up. The consequences of that have been bad for just about everyone bar Intel. AMD itself has been marginalized to the bottom end of the CPU market. Even fans of Intel CPUs would have to admit that the lack of tough competition from AMD has seen CPU performance somewhat stagnate and prices creep up.

Symptomatic of that is Intel's current desktop CPU range. The top end now stretches to a staggering $1,700 for the Core i7-6950X. The most expensive AMD CPU is just $250. All the while, Intel's mainstream CPUs, the ones most of us use, have been capped at four cores for what seems like an eternity. In other words, what the PC needs is a shake-up, and only AMD can deliver that.

The kicker is that AMD can't afford another failure, another prolonged period of selling processors at knock-down prices. AMD doesn't need to blow Intel away, but it does need to be in the mix with processors that are at least competitive with the top end of Intel's mainstream chips. AMD has been revealing ever more about Zen in recent months, so we now have a detailed picture of what it looks like on paper. And it's very promising indeed.

AMD IS BACK. So says Mike Clark, one of AMD's big brains, and lead architect on the new Zen CPU design. But back from what? The story of AMD's new Zen CPUs is all about context—what you need to know to understand how we got here, why Zen is so important, and why we still need to be cautious with our expectations. Not to put too fine a point on it, of late, that context involves failure.

But let's not get ahead of ourselves. Actually, this story really begins with success. Without going right back into the annals of AMD's history as a maker of Intel x86 processor clones and its occasional early victories, the big tipping point for modern AMD chips was the launch in 2003 of the K8 CPU architecture, otherwise known as Hammer. For the first time, AMD had a CPU that was unambiguously better than Intel's.

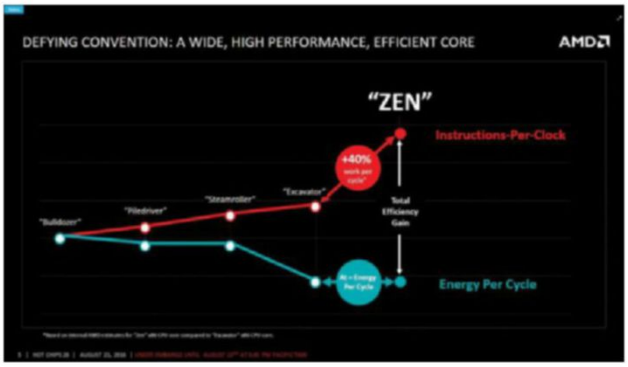
It performed better in many tasks. It was more advanced. It was more forward-looking. It was even conceptually more elegant. It was a brilliant bit of work. Indeed, thanks to its innovative 64-bit extensions, Hammer pretty much nailed down AMD's cross-licensing relationship with Intel for the foreseeable future. Intel adopted AMD's 64-bit extensions, known as AMD64, from Hammer, and in the process endowed a deeply interwoven, even symbiotic, character to its relationship with AMD. Put another way, it's almost unthinkable that Intel would drop AMD64 in order to lock AMD out of any future extensions it may itself bring to x86. AMD's place at the x86 table was secured by Hammer.

In fact, you could argue that AMD would have been better off sticking with Hammer, even up to the present day. But that's only true because of the near-catastrophic failure of the follow-up to Hammer, known as Bulldozer. It feels like a lot more than just five years ago, but Bulldozer was first released in late 2011. AMD has tweaked the Bulldozer architecture over time with the Piledriver, Steamroller, and Excavator revisions, but the basic concept remains the same today.

CORE STRENGTH?

That concept involved a radical new modular architecture that saw the very idea of what constitutes a CPU core reinvented. AMD ditched the notion of monolithic cores and replaced it with modules, each containing a pair of integer processing resources and a shared floating point unit. The idea was to take Intel's Hyper-Threading technology, which enabled a single core to process two software threads in parallel, and turbo-charge it.

The problem was that it didn't work. Bulldozer's multithreading performance was reasonable, but its single-threaded throughput was hopeless, and absolutely miles off the impressive pace Intel had been setting with single-threaded performance since the launch of the Core 2 Duo chip in 2006. The long-term impact of that failed architecture can still be seen today.



Efficient performance is AMD's dual-pronged plan for Zen.

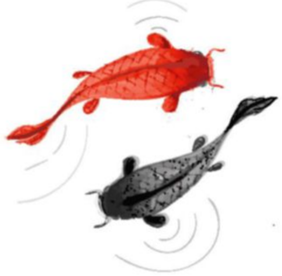
At the time of writing, AMD's highest performing desktop CPU, the FX-9370 Black Edition, is a $250 chip. In other words, AMD isn't able to price the 9370 even on a par with the bottom end of Intel's quad-core Core i7 processors, let alone the likes of the 10-core, $1,700 Core i7-6950X. In short, AMD is barely in the mid-range game, let alone keeping Intel honest across the board.

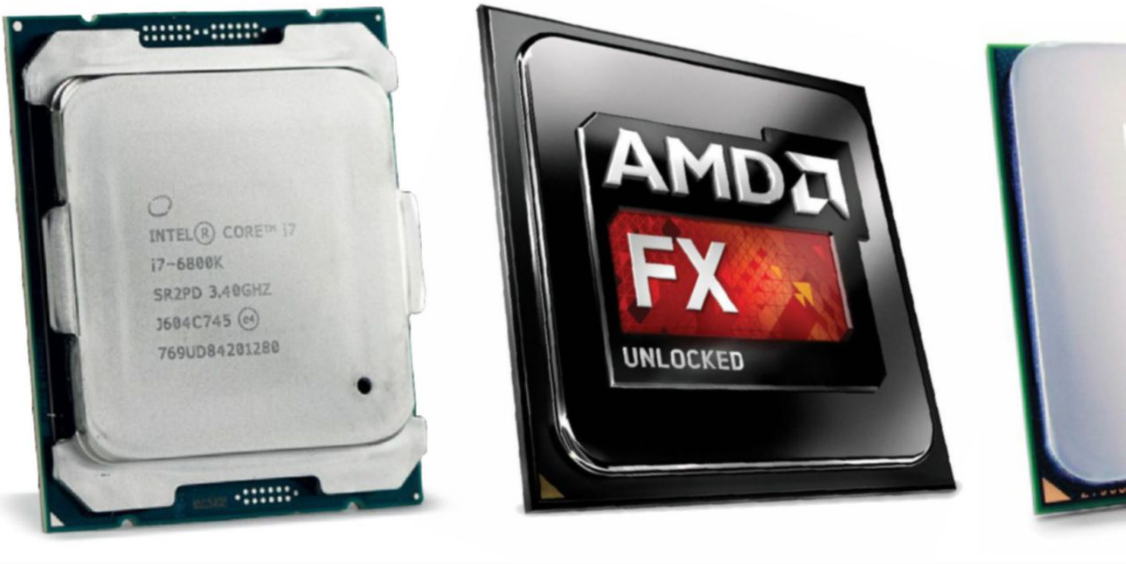
So, the all-important context for Zen is the fact that AMD hasn't wheeled out a truly successful new CPU architecture since 2003. But there's one final twist to this background story. The chief architect on the AMD Hammer architecture was Jim Keller, a microprocessor engineer who also has AMD's original Athlon CPU, along with Apple's A4 and A5 chips, on his impressive résumé, and now works at Tesla Motors as vice president of Autopilot Hardware Engineering. Keller returned to AMD in 2012 as chief architect. Zen is Keller's baby.

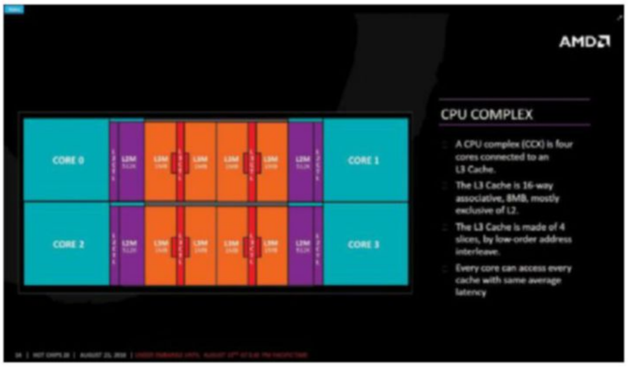
But what, exactly, is Zen, and why is it so promising? At a very high level, Zen is a return to a more traditional approach to PC processing. Gone is the radical modular approach introduced by Bulldozer, replaced by conventional cores designed to crunch through as many instructions per clock cycle as possible. Intriguingly, Zen also includes support for simultaneous multithreading. Each Zen core can process two threads in parallel.

So, Zen looks an awful lot like a modern Intel chip—big, powerful cores with multithreading support. But what about the details? According to AMD senior fellow and one of the lead architects for Zen, Mike Clark, it's a genuine clean-sheet design, and it's all about balance. "Zen means balance. As designers, we have a set number

From left to right:
Intel's Broadwell-E beast is the target for the first Zen chips.
The Bulldozer FX experiment basically bombed.
Remember the good old days, when AMD's Athlon 64 ruled the world?







CPU COMPLEX

- A CPU complex (CCX) is four cores connected to an L3 Cache.
- The L3 Cache is 16-way associative, 8MB, mostly exclusive of L2.
- The L3 Cache is made of 4 slices, by low-order address interleave.
- Every core can access every cache with same average latency

Don't mention the modules—AMD now prefers the term "complex."

of transistors to work with. So, the design process is about trying to build the best core you can, while balancing competing principles such as frequency, work per clock cycle, how much power you're burning, the impact of new instruction sets, and so on."

However, Clark says AMD had a particular target in mind. The aim was to increase the number of instructions the architecture could process per clock cycle, otherwise known as IPC, by 40 percent over existing AMD cores, without increasing power consumption per cycle. "We realized that a derivative of Bulldozer was not going to get AMD to where it needed to be," says Clark.

So a ground-up design it was, and one based on three pillars that would enable that 40 percent uptick in IPC, without increasing power: a new, improved CPU core design, improved cache memory, and low-power features designed in from first principles.

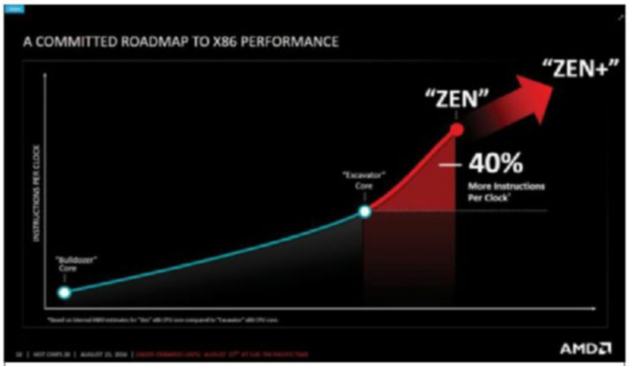
FLOATING IDEAS

Improvements to the core are so extensive that AMD could and probably will write a book on them. But the elevator pitch includes everything from multithreading, improved branch prediction, and wider micro-operation dispatch to larger instruction schedulers and fully resourced integer and floating point units.

Of course, put like that, it all sounds like digital double-speak. But, broadly speaking, most of the improvements fall into one of two camps. The first is avoiding wasted CPU cycles. That's where features like improved branch prediction come in. Better prediction makes it possible to speculatively process code branches, without wasting CPU cycles doing work that ultimately isn't needed.

The second major effort involves maximizing the theoretical capacity of the processing engine. That takes many forms. The

AMD
64
Athlon X2



A COMMITTED ROADMAP TO X86 PERFORMANCE

JUST HOW FAST IS ZEN?

The theory is all very well. In theory, AMD's Bulldozer was going to be a killer multithreading machine. It didn't quite work out that way. So, despite AMD's extremely plausible sales pitch for the new Zen architecture, the proof will be in the real-world performance.

Inevitably, we won't have the full picture until next year at the earliest, when the first Zen CPUs are released, and we can verify all the impressive claims first-hand. But AMD has provided a glimpse of what we can expect beyond that headline claim of 40 percent improved performance per clock, compared to its existing CPUs in single-threaded software.

At the traditional sideshow event it holds in parallel to the main event at Intel's IDF tech fest in San Francisco every year, AMD demonstrated Zen running a benchmark in public for the first time. The setup involved an eight-core Zen chip running alongside an Intel Broadwell-E processor, also with eight cores. Because both chips support multithreading, this was a 16-thread contest. Also, both chips were running at a nominal 3GHz, the idea being to demonstrate the per-core and per-clock performance of the two architectures.

The benchmark on the day was Blender, an open-source rendering engine, with a custom multithreaded workload. And the result? Zen completed the test in 48 seconds to the Intel chip's 49 seconds. A narrow victory, to be sure, but loaded with portent.

Of course, there's a number of ways to look at the result. You could argue that matching Intel with an unreleased chip isn't all that impressive. Who knows where Intel will be by the time Zen appears? What's more, not only is it just one data point, it's also a custom benchmark that's prone to tweaking to make AMD's architecture look good.

But we'd prefer to be optimistic and note a couple of things. First, Intel's performance gains in recent generations have been pretty incremental, and it's unlikely that it has all that much in hand bar the addition of further CPU cores. But, more importantly, AMD doesn't need to match, much less beat, Intel to make the CPU market much healthier. It just needs to close a big chunk of the current performance gap. On this early showing, it looks very likely that Zen will meet that basic expectation.

SPEEDS AND FEEDS

So, you've got a broad picture of what AMD's new 14nm Zen architecture looks like. What will the detailed specifications of the first chips be?

Unfortunately, AMD isn't going into any great detail at this stage. But there is enough information out there for us to take a stab at the likely configuration of the first retail Zen chips. In terms of core count, the 8 cores and 16 threads of the processor that AMD demonstrated beating Intel's Broadwell-E, a chip that's currently codenamed Summit Ridge, probably represent the initial high-end target for AMD.

It's not that Zen is necessarily limited to eight cores by some technological limitation. Indeed, AMD has released details of a massive 32-core Zen chip called Naples. But that's designed for high-end servers. Moreover, the Zen architecture is based on quad-core modules—a word we hesitate to use, thanks to its association with the failed Bulldozer architecture, and, indeed, AMD is avoiding in favor of quad-core "complex." Whatever, AMD isn't in the position, financially, to tape out endless variations of the Zen architecture, at least not initially. So we expect single and dual-module Zen chips for PCs at launch, and hence quad and eight-core CPUs.

The modules in this case are centered around Zen's cache implementation, and specifically its 8MB of shared L3 cache per quad-core module. From that we can say that the first eight-core Zen chips will almost certainly have 16MB of on-die L3 cache, although it is possible that AMD may opt to fuse off some of that cache in at least some models, especially if early production yields are proving problematical.

As for clock speeds, that really is the great unknown. Again, that benchmark demo provides a yardstick, with the Summit Ridge Zen chip running at 3GHz. That's decent for an early engineering sample. All AMD will say is that 3GHz isn't the final clock speed at which it expects to ship the first Zen processors. And all we can say is that as long as Zen tops 3GHz in eight-core trim, it is likely to be a very interesting chip indeed.

most obvious involves that Hyper-Threading-like multithreading capability that gives each core support for processing two threads simultaneously. Zen is also what's known as a wide machine. That means it has support for significant internal instruction processing parallelism. The main features here include four-wide instruction issue and six micro-operation dispatch per cycle. AMD has also given the design some serious execution parallelism. Each integer unit has four ALUs and two AGUs, while the floating point unit has four execution pipes, each with a 128-bit data path.

AMD's efforts to maximize the capacity of the engine are also visible at a higher level. Generally, AMD has upped the capacity of the architecture with larger schedulers and bigger registers. But, in contrast to AMD's Bulldozer chips, the two main paths through each core—integer and floating point—are fully resourced.

By that we mean the approach taken by Bulldozer, in which a pair of integer units shared a wide array of resources, including schedulers and a floating point unit, is gone. For Zen, each core has its own independent integer and floating point units, and each unit has its own schedulers, registers, and execution pipes.

If that's what you might call Zen's "engine," the next problem and the next design pillar involves keeping that engine well fed with data. That's where Zen's overhauled cache memory architecture comes in. Again, many of the details are nuanced to the point of needing a master's in integrated circuit design to fully appreciate, but there are some broader themes we mere mortals can grasp.

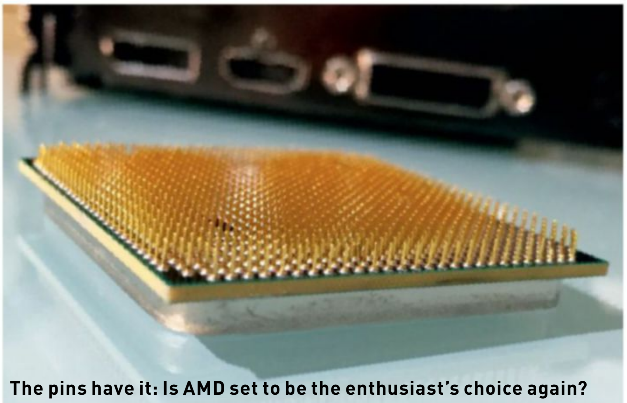
FASTER, FASTER

Here, AMD had two main aims: quicker and faster. If that sounds like two ways of saying the same thing, it isn't. Not quite. In fact, it's the difference between latency and bandwidth, which are subtly and yet substantially different. Latency is all about response—in other words, how long it takes the cache memory to respond to requests for data. That's all sewn up in the fine detail of the cache design, including features such as the cache prefetchers. Long story short, the less time the cores spend waiting for the cache to respond, the quicker the cores can get to work.

Of course, quick responses are all very well, but they won't get you very far if the resulting performance is poor, which is where bandwidth comes in. AMD has doubled the bandwidth of the level one and two cache in Zen compared with its previous designs. Zen's level three cache is even faster. It has five times the bandwidth.

Put all that together—the totally redesigned engine in the shape of the core, plus the cache memory that feeds it—and you end up with that 40 percent figure for IPC. The other part of AMD's ambition with Zen and also the third and final pillar of its design is power efficiency. In other words, achieving that 40 percent uptick without a massive increase in power consumption.

Part of the solution is AMD's long, long overdue jump to a new manufacturing process. Did we mention how long overdue that


The pins have it: Is AMD set to be the enthusiast's choice again?

is? AMD has been stuck on 32nm and its 28nm half-node cousin for so long it was getting embarrassing. But Zen is being built on the new 14nm FinFET process from manufacturing partner Global Foundries, as already seen with AMD's latest Polaris graphics chips, including the Radeon RX 480.

But there's more to Zen's power efficiency than process. Mike Clark says that Zen is AMD's first high-performance processor that's built for power efficiency from first principles. That's arguably something Intel has been doing for a decade. Whatever, Clark reckons AMD has done such a good job, Zen will be able to replace Bulldozer as a performance architecture, and AMD's low-power Jaguar architecture, too. One architecture to rule them all.

PLATFORM GAMES

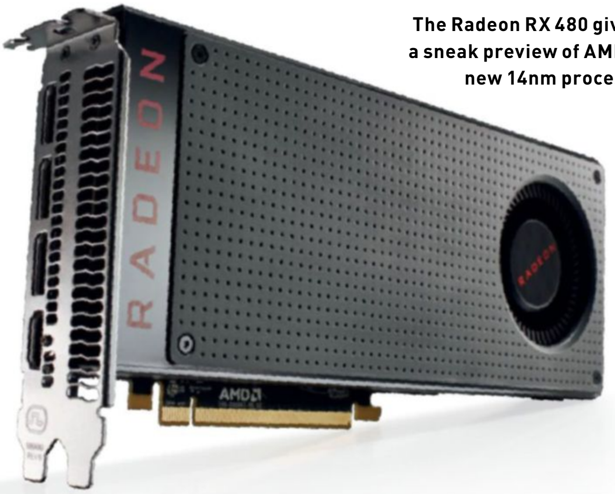
The final part of the Zen hardware puzzle is the platform. AMD's desktop chipsets are looking pretty ancient these days. While Intel presses on with native support for features such as DDR4 memory, PCI Express storage with NVMe capability, and the like, AMD has been largely rebadging its existing chipsets, and papering over the cracks with add-in chips.

Clearly, AMD has plenty of catching up to do here, but as yet, it's not known exactly how it will approach the problem. Internet rumors suggest that AMD has integrated much, if not all, of what is traditionally found in the south bridge chip—including features such as USB controllers—into the Zen CPU die. However, those same rumors claim this area of the chip has been causing problems, with motherboard makers apparently looking into using add-in chips as an interim measure.

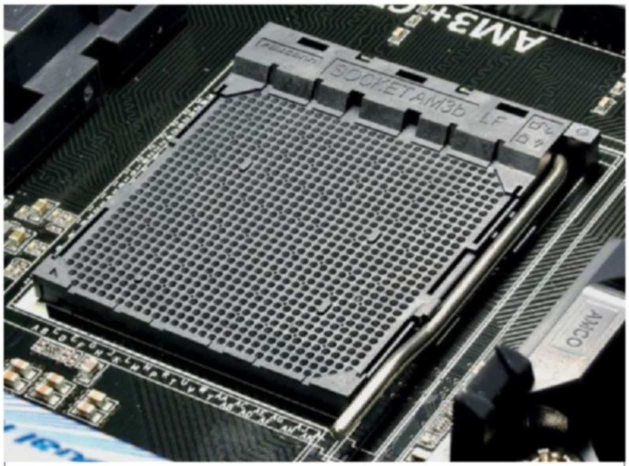
Indeed, it's possible this explains the one big remaining worry concerning Zen: When will it appear? Like so many AMD projects, Zen is running a little behind schedule, having originally been due in 2016, and has now slipped into early 2017 as things currently stand. Cause candidates include the aforementioned chipset integration issues, and the shift to that fancy new 14nm process. The former is a one-off issue that will certainly be solved, the latter is a little more worrying, especially if it impacts clock speeds. What's more, the modest clock speeds of AMD's new 14nm GPU, versus Nvidia's 16nm, aren't exactly confidence-inspiring.

But that one caveat aside, the overall picture looks promising, if not tantalizing, especially if you factor in the early glimpse of performance from AMD. If Bulldozer was a gamble, a bold step in what turned out to be the wrong direction, Zen looks like a very carefully considered assault on everything that has given Intel its advantage in recent years. If Zen succeeds, it'll reshape the PC processor landscape for years to come, force prices down, and leave Intel no option but to up its game.

We'll leave the last word to Mike Clark: "Zen is not a destination, it's a starting point. AMD is back and totally committed to high-performance compute." Bring on 2017! ⏻



The Radeon RX 480 gives a sneak preview of AMD's new 14nm process.



AT LAST, A NEW PLATFORM

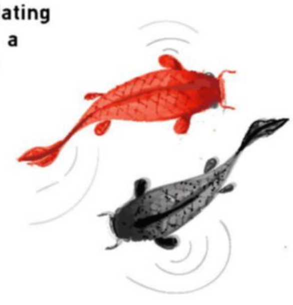
AMD's Bulldozer processors take a pounding for their poor performance. But, let's be honest, AMD's chipsets have hardly covered themselves in glory of late.

Even the ostensibly high-end 990FX is absolutely ancient beneath a layer of badge engineering that is fooling nobody these days. How could it, when it conspicuously lacks so many features, including DDR4 memory support, PCI Express 3.0, USB 3.1, and the NVMe protocol for solid-state drives?

The good news is that all of that is coming with AMD's new chipsets for Zen. Beyond that, we can't tell you much about the detailed specifications. However, the other good tidbit of news is that AMD is also consolidating its CPU socket strategy.

Currently, it's a bit of a mess, with FX processors requiring Socket AM3+ motherboards, while its Bulldozer-based APUs need Socket FM2+ boards, and cheaper APUs derived from ye olde Hammer architecture take boards with AM1 sockets. All that is going, replaced by a single AM4 socket that will be compatible with both high-performance Zen processors, such as Summit Ridge, and its upcoming APUs, codenamed Bristol Ridge.

Given that socket stability used to be one of the big attractions of AMD platforms, in contrast with Intel's constant and infuriating tinkering, that's certainly a very welcome change. If Zen can also deliver on the performance side, it really will be a return to the good old days of the Athlon 64, when it was AMD that made the running with an awfully appealing all-round package for enthusiasts.



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TECH PORN

HP Omen Laptop 15t Gaming UHD

OUR HUNT CONTINUES for the perfect gaming laptop. Or, to be more specific, a thin, lightweight, powerful ultrabook. One that's not too big, not too loud, and capable of playing the latest and greatest games at 1080p and above. It's a lot to ask. We've never seen one so far—and, in reality, with today's technology, you're simply not going to get all that from a laptop. And it isn't likely to change anytime soon, either.

That said, with the gaming industry's continual push for higher performance and better frame rates, these trends are starting to influence the world of ultrabooks, forcing manufacturers to couple sleek workstation notebooks with the best and brightest technology the gaming world can offer. So, let's welcome HP's Omen series of notebooks. Coming with a 15-inch 4K IPS screen, an Intel Core i7-6700HQ, 16GB of DDR4, and a GTX 965M, this is almost the perfect workbook.

Yes, the Omen lineup is aimed at gamers. The carbon fiber finish, accompanied by the Polynesian tribal logo adorning the chassis, is proof enough of that heritage. But, like Intel's NUC from the previous issue, it's better suited to a professional. Its glorious form factor, delectable screen, solid processor, and speedy NVMe PCIe SSD makes this 15-inch beauty a stunningly well-placed value acquisition for anyone looking to buy a nifty little laptop to work on in the office, and game on in the evening. **–ZAK STOREY**

1 GTX 965M GPU

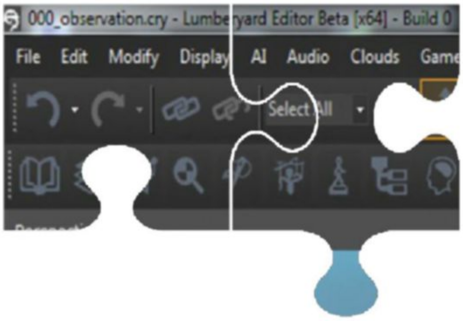
Yeah, we know: 4K screen, GTX 965M—why would you do that? Just think of the pixel density here: 4K on a 15-inch panel is 293 ppi. That's twice as compact as a 28-inch equivalent. The theory is that you game at 2560x1440 and below, and enjoy the desktop experience at 4K.

2 4K IPS PANEL

Is there anything prettier than an IPS panel when it comes to accurate color reproduction, short of OLED? Probably not. This is positively the best you're going to get when it comes to working on a notebook.

3 CARBON FINISH

OK, yes—this is the gamer aspect we commented on earlier. Fortunately, it's not garish, but a clean, matte, subtle finish. Props to HP for really nailing the aesthetics on this. We just wish the rear logo was LED-lit instead....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ENGINES OF CREATION

The present and future of game and VR world generation

By Daniel Griliopoulos

Every universe has its own basic set of rules. Middle-earth has magic, *Star Wars* has midichlorians (AKA magic). Ours has things like gravity, the Planck constant, and so on. The outgrowth of these simple rules creates complexity—rainbows, computers, seacows….

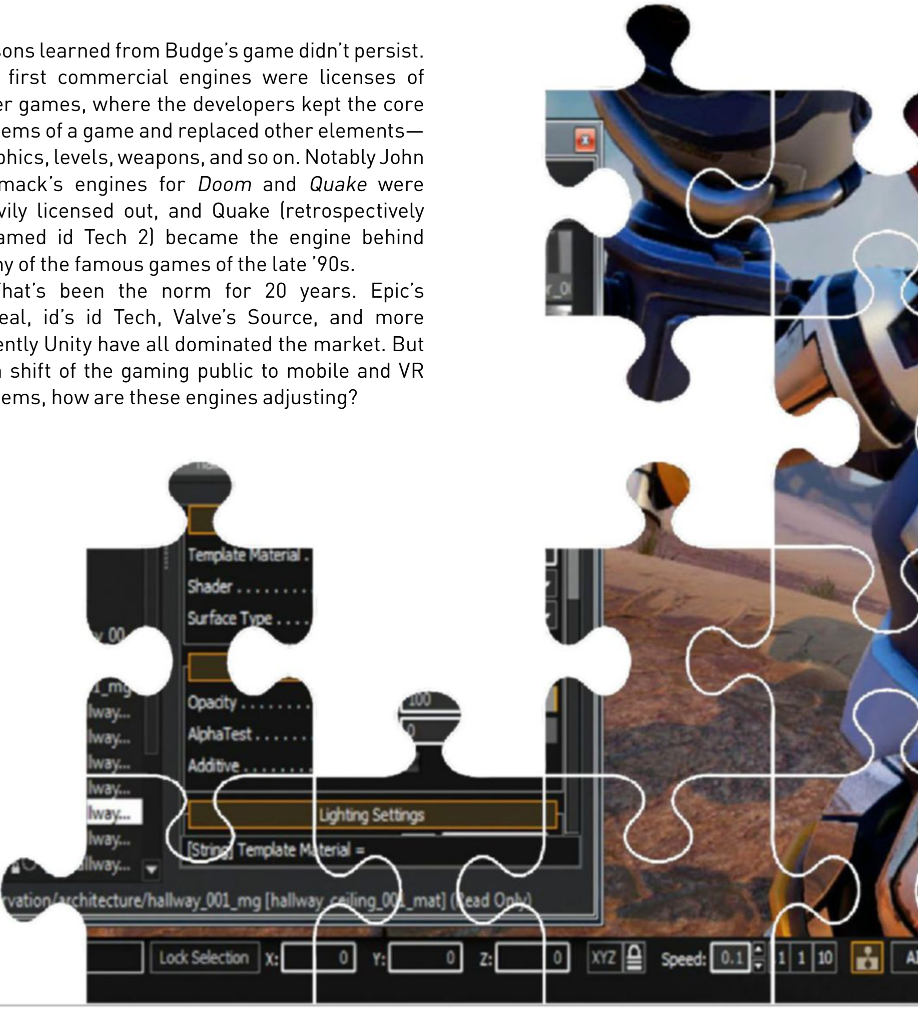
Game universes have their own rulesets, too. The existence of magic, the presence of gods, or perhaps faster-than-light travel. However, these aren't the basic rules of the universe, but glosses on it. The basic rules of a game universe are dictated by the underlying engine, and those basic rules can be a lot more simple than a real-world universe (so far, anyway). They can range from how many dimensions the universe has (GameMaker is 2D, the CryEngine is 3D) to the look of the worlds in it (RPG Maker is low-res, Unreal is high-res).

Games weren't always built on engines. You used to start from scratch each time, because the games were built on hardware systems with very limited resources—extreme memory constraints or display systems, say—which didn't leave wiggle room for the data-driven systems of game engines.

So, the first game engines were as much games as engines; 2D or limited 3D titles, such as GameMaker in 1985, or 1988's RPG Maker.

But the first and best known was Bill Budge's iconic 1983 game *Pinball Construction Set*, which let players create a virtual pinball table. You could save the result to a floppy disk and give it to friends to play—even friends who didn't have *Pinball Construction Set*. It was easy to use, flexible, and included one of the best early GUIs. However, the lessons learned from Budge's game didn't persist. The first commercial engines were licenses of other games, where the developers kept the core systems of a game and replaced other elements—graphics, levels, weapons, and so on. Notably John Carmack's engines for *Doom* and *Quake* were heavily licensed out, and Quake (retrospectively renamed id Tech 2) became the engine behind many of the famous games of the late '90s.

That's been the norm for 20 years. Epic's Unreal, id's id Tech, Valve's Source, and more recently Unity have all dominated the market. But with shift of the gaming public to mobile and VR systems, how are these engines adjusting?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Few people know as much about game engines as Tim Sweeney. He founded Epic in 1991 as a shareware company, then personally wrote much of the first-generation Unreal Engine. As CEO, he's led the company's efforts at licensing out Unreal Engine, which is probably the most successful AAA game engine ever. Yet even he feels that there are major challenges to game engine design.

"It's always changing!" Sweeney tells us. "We're constantly supporting the influx of entirely new types of developers—from pros, to modders, to indies, and now enterprise users. And the platform dynamics are changing, too. The early iOS and Android days created an indie gold rush, which is now under severe pressure as growing game budgets and user acquisition costs force smaller teams out of the mobile business and into either the realm of hobby development, or to new commercial frontiers, like VR and AR. Each step in the industry's evolution requires engines to adapt rapidly, or face rapid decline."

When engines were first released, the market was pretty flat—you had one-man programmers, small studios, and that was it. Now engines have to cater for that one-man programmer, small studios, and 3,000-strong teams (AKA enterprise users). That's a huge range, but Sweeney thinks Unreal can serve it. "What is most important in engines is to balance ease of learning with delivering sufficiently scalable tools, features, and stability that developers can productively ship highly successful games." Unreal Engine 4 is designed to work for one-man bands and scale up to teams of hundreds across multiple locations, integrating with industrial-class revision control software, such as Perforce, as well as distributed tools such as Git.

Superhot's **time-bending mechanics and look conceal the Unity engine well.**

The mobile game revolution is also having a big, shifting impact on game development, which bleeds over into engines. Mobile game success has become about money—how much you're willing to spend on "buying" users—which has become a huge barrier to new or independent developers. That means engine designers, like Epic, have to decide whether it's worth supporting those platforms. After all, if only a few companies are making money on a platform, no one else can afford your engine.

"You can't be strong everywhere," says Sweeney. "We've explicitly chosen to be strong on platforms that offer developers significant commercial opportunity—with world-class support for Oculus, Vive, PlayStation 4, Xbox One, PC, Mac, iOS, Android, and now Daydream VR. That meant abandoning legacy smartphone and console platforms, and we're OK with that."

ALTERNATIVE MOTORS

Looking at Unreal's competitors, you can see they're similarly trying to differentiate themselves. GameMaker, CryEngine, Source—they're almost all free to non-commercial developers, with an array of different royalty and pricing structures for commercial use. Some take percentages, some cap how much profit you can make, some just require you to pay a monthly fee.

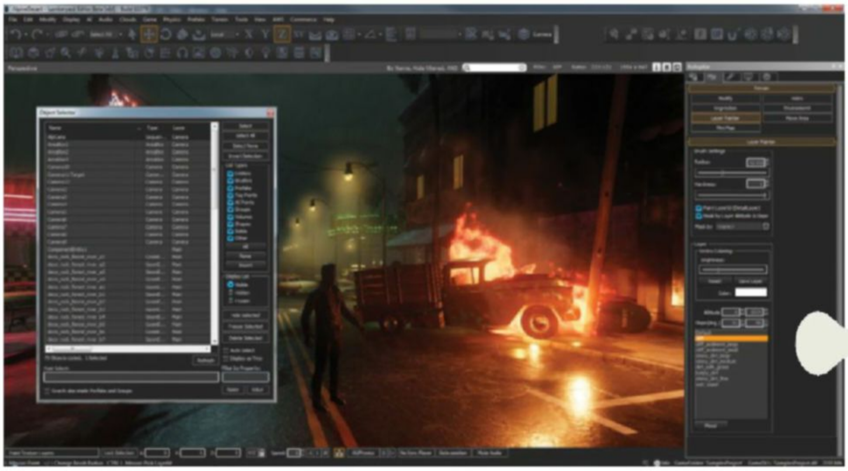
Modern game engines can produce photorealistic graphics—if you have a great artist.

The largest alternative motor is Unity, which has become the small developer's engine of choice. "We bring a great engine to the table, not to mention 10 years of experience," says Marcos Sanchez, head of global communications at Unity. "We want to make it easier for people to create without having to do a lot of coding, and the more we can offer that, the more people can focus on telling stories, while producing games and experiences that just work."

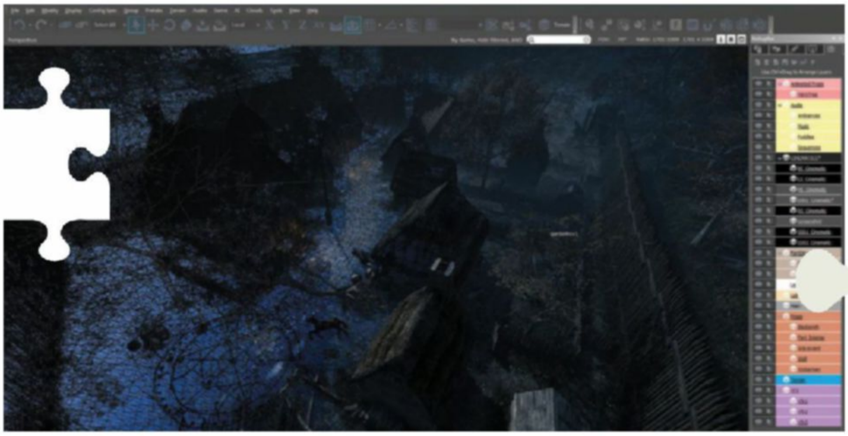
One notable new entrant to the market is Amazon. As it admits, its Lumberyard engine isn't really new—it's made up of technology from Amazon Web Services, CryEngine, Twitch, and Amazon's Double Helix game studio. "First, developers want a great core engine," says JC Connors, Lumberyard's principal product manager, "which means great performance, workflows that enable developers to iterate quickly, flexibility to customize the technology, and the ability to create the quality of game that matches their vision, whether it's an old-school homage or a phenomenal AAA game."

Lumberyard has all that, but it's also integrating with the modern systems gamers use to play their games. Connors explains: "Lumberyard is a AAA game engine deeply integrated with AWS and Twitch, so in addition to all of the engine components developers expect, such as animation, particle systems, physics, and so on, Lumberyard also provides technology to make it easier for developers to build live, connected, and multiplayer games."

Live games are Lumberyard's specialty because the team estimates that 85 percent of PC and console games have multiplayer. "Games are becoming lifestyles," says Connors, "with players, fans, broadcasters, modders, and spectators participating in



Amazon's Lumberyard is composed of elements from older game engines.



WYSIWYG engines such as Lumberyard enable designers to edit running games.

a complex relationship with developers… New game genres are emerging out of this community behavior—esports, Twitch Plays Pokémon, and so on."

THE INDEPENDENTS

Despite their name, many "independent" developers use off-the-shelf engines. As indie game and engine designer Erlend Gresfrud explains, it makes sense. "Licensing a cross-platform general-purpose engine is an investment in safety. You can assume it works, and if it doesn't, it gets fixed. If you don't understand what's going on, you can call the vendor or other developers. There are regular updates. You don't have to juggle a technology strategy and a product strategy. What are you doing—making games or game engines?"

Of course, some people are succeeding without using these major game engines. Many indie developers have perfectly good reasons for not using off-the-shelf tech.

The first reason is aesthetic. Engines tend to have a dominant aesthetic, which is hard to remove. At its peak, every game made on Unreal looked a bit like *Gears of War*. "It's hard enough to make your game stand out as it is," says Cliff Harris, creator of *Democracy*. "Using the exact same tools, shaders, and code as everyone else makes it even harder."

Another is bloat. Early games had very tight memory limits to hit, so had to be hand-coded to fit. As Harris explains, that problem continues. "With an engine written by someone else, it has to be generic. They have no idea whether you are making a side-scrolling platform game, a first-person shooter, a city builder, or a card game. You need to construct code that is way too bloated for a simple card game, probably not optimized enough for CPU/memory for a city builder, not graphically optimal for an FPS, and so the list goes on."

Bug-fixing also becomes easier. As *Maia* creator Simon puts it, "When they work, they work well, and save you massive amounts of time and energy, but when they fail, they create an often insurmountable brick wall. Issues that would be fixable with a few hours of programmer time put a full stop in development until the engine provider deems the issue worthy of a fix."

By creating an engine just for his game, Harris can keep it faster, cleaner, and

THE LEADING ENGINE

Although Unreal is surely the most powerful game engine out there, its upstart competitor Unity has overtaken it in recent years. A McKinsey report puts Unity at 45 percent market share, with 47 percent of developers using it—three times its nearest competitor. The firm also claims 4.5 million registered developers who have made games for nearly 600 million gamers. (Which isn't such a great statistic, if each developer is only reaching 133 people on average with their game….)

That's odd, because Unity is only 11 years old—half the age of Unreal, id Tech, and CryEngine. So why would it have such a huge advantage? Well, firstly, it's got a huge asset store, where developers can upload and sell their own stuff, as well as buy other people's 3D models, scripts, extensions, shaders, audio, animations, and so on. There are over 15,000 assets on there and we know developers who make their living from this library alone. Secondly, it's really easy to learn and quick to develop on—without knowing any code, we've altered variables on collaborative projects to improve gameplay.

Unity's PR statistics reveal something more interesting, though. There might be 47 percent of developers using Unity, but just 29 percent use it as their primary tool—and more developers use no game engine at all, with 38 percent programming primarily in either native code or using a custom solution. That fits with our indie experts' descriptions of their experiences—that if you know enough code, have enough time, and/or are making just a single game, it's better to build an engine from scratch yourself.

SWEENEY ON EVERYTHING

EPIC'S FOUNDER HAD MORE WISDOM THAN WE COULD PRINT

On engine standardization
The lesson of standardization is that a technology needs to stabilize on a common agreed-upon feature set first. Since their inception, engines have evolved far more quickly and diversely than programming languages or the web, which have been successfully standardized. It is realistic to view engines as existing one level above standardized technology. Unreal Engine 4 is built on the C++11 standard, the OpenGL and Vulkan standards, and numerous other official and de facto standards. Areas for future standardization include data interchange formats and network protocols. However, trying to standardize codebases behind some sort of "OpenEngine" API would, at this point, be madness.

On engine graphical constraints
It's true that engines could benefit from more use of GPU compute and more CPU/GPU parallelism, but there are trade-offs involved. Engine design balances two competing priorities: extracting the maximum performance out of hardware, and providing maximum productivity to developers building games. To design an engine to utilize hardware much more efficiently, developer productivity would suffer, and on balance, that would detract from game quality.

On cloud computing
Cloud computing gives developers access to effectively unlimited computing power, but it's not free, and the programming model behind co-ordinating thousands of loosely-coupled servers is itself very limited. So far, the cloud has been used for fairly traditional back-end server tasks. We'll see if social and VR applications push it further in the future!

On middleware
At Epic, we have always been happy to use middleware, open source libraries, and standards wherever they provide an effective solution to the problem at hand. Open interfaces for analytics, profiling, ad networks, and other components have proven quite successful. Version control may be the area that is most ripe for innovation. Perforce and Git provide great solutions for traditional workflows, but we will need something that will scale to the metaverse, and nothing currently comes close. The next step is to add further real-time integration, to give developers real-time situational awareness.

Tim Sweeney founded Epic, and is one of those rare CEOs who understands his entire product, right down to the code.

smaller than an off-shelf-engine. Partly, this is because Cliff normally builds games for just one platform—the PC. "The fact that an engine lets me make a game that theoretically runs on an iPhone doesn't mean my GUI, game design, or business model works on iPhone, nor does it get me out of paying the Apple developer fees or dealing with the Apple admin, or having to deal with bugs that crop up only on iOS."

That said, there are some benefits to creating an engine that persists between games, as Ashley Gwinnell, creator of *Friendship Club*, has found. "A lot of features underlying game programs are the same. Windowing, math, scene graphs, pathfinding, and so on, once implemented, rarely need to change. It makes sense to share these functions between projects."

Indeed, Gresfrud has gone a different route, constructing an open-source game engine called Rainbow almost completely out of open-source tech. "We started building the engine part for organizational expertise, in part because there were few viable open-source multiplatform engines with nice open-source licenses. You only make your own engine because you need to, or because you are lucky enough to enjoy writing engines and have the means to take your time doing it, or because you have a technology strategy."

However, even the other hardcore indies do miss some aspects of the big engines. For example, Harris can understand the appeal of the array of third-party shaders and generic art available on large game engines, and the speed of prototyping. Gwinnell misses having a visual editor, which allows a programmer to collaborate better with artists and designers. And Roth says, "Developing your own engine is tens of thousands of man hours of work. If you know there is an engine that will do roughly what you need, with no major issues, and the tools effectively slot into your pipelines, game development can be massively expedited." But none of these things outweighs what they love about creating their own code from scratch.

REBORING THE ENGINES

Even if developers step away from mainstream engines, there are new markets waiting to take over. Many fields need effective modeling of the real world, that can be animated and obey the laws of physics. Game engines can model physics, appearance, sound, movement, collision, multiple human or AI agents, and more.

Sweeney's Unreal Engine is ahead of the curve on that, with several major firms using it for non-games technologies, as he explains. "McLaren has been leading the way with Unreal Engine 4 for automotive design visualization and car configuration. Networks like Nickelodeon are using it for creating television experiences, integrating video streams with real-time audience participation. Disney Imagineering is using it in designing *Star Wars* VR experiences for Disneyland and Walt Disney World theme parks. And architects, consumer product designers, and training simulators. We're rapidly seeing the development of a real-time content industry encompassing the game industry and many other spaces."

Connors agrees: "High-fidelity, real-time 3D is a fantastically useful tool for architectural previews, movie previsualization, complex simulations, and probably use-cases we haven't imagined yet." And, because of their relative ease of use and wide-ranging compatibility with other software, game engines are perfect.

One element that's changing is displays. "What we've seen is an explosion of display complexity, with the emergence of VR, HDR, 4K, 8K, and so on," says Connors. "The Lumberyard team is investing heavily in graphics technology to help our customers take advantage of these displays."

VR, like the multimedia products of the 1980s, is promising to be another cross-media platform, but one that makes heavy use of games technology—and hence engines. But there are big challenges, according to Sweeney: "VR and AR are unique in that they change the rules of game design far more fundamentally than mobile gaming and touchscreens did. We now have the power to create completely immersive experiences, but this imposes far more stringent requirements on performance, visual fidelity, and player motion."

Connors is in agreement: "Developers have to build experiences that can maintain a steady 90fps and still be visually delightful. Because presence is so critical in VR, developers can't take shortcuts with flat 2D sprites or low-quality textures."

Sweeney thinks engines need to be ready for an even bigger step: the metaverse, a VR space where users can interact with each other. "It's a problem that's perfect for UE4, as a high-performance C++ engine that originated in high-end PC and console gaming. On the gaming side, wiping the slate clean in terms of design experience provides a huge opportunity for new developers to pioneer new ideas. The hardest problem engines must solve is to enable a billion users to participate in immersive social experiences, with a large fraction of them content and interactive experiences. This requires significant advances in networking technology, digital humans—on the input and output side—user-friendly tools, and lots more. The leading-edge is moving quickly."

Unity's Sanchez is confident this is coming soon. "The concept of a metaverse is absolutely one we think will happen, where people will create their own worlds, or meet people in worlds created by others. We're not so far away. Our perception of 'reality' exists based on electrochemical signaling; VR, like a dream, can potentially trick the mind into forgetting what is real, and what isn't. We're all just electrons at the end of the day (even that VR headset), or as Joni Mitchell says, we are stardust."

Epic's *Paragon* uses Unreal Engine to power a killer FPS-MOBA.

THE MIDDLE GROUND

The game engine market lives and dies on "middleware." This is extra software designed solely to do very specific things, mostly across several game engines. (NB: The term "middleware" in other contexts is a synonym for software.) It's what old science fiction called a "subsystem."

For example, have you ever wondered why trees look so similar in both games and movies? What is it that the trees in *The Jungle Book* movie, *The Force Awakens,* and *The Witcher III* share? That's down to SpeedTree, a software product made by IDV Inc, which has become the norm for generating believable-looking trees across Unreal 4, Unity, Maya, 3ds Max…. Even architects use it. The company makes its money selling a full software package for $5,000, or subscriptions for plugins at $20 a month—as well as offering a range of different tree types for all different biomes at low prices.

Other middleware takes different roles away from the main engine. Bink allows for in-game video rendering, Scaleform allows the programmer to create simple user interfaces, Havok provides in-game physics and animation, and FMOD lets users manage their audio files and edit them. Some middleware is more subtle—Fork Particle renders particle effects, such as smoke, in real time, while Umbra and Simplygon both manage the amount of detail a game displays in different, smart ways. Finally, there's even networking middleware, enabling you to turn your single-player game into something multiplayer, or even massively multiplayer.

Beyond middleware, game assets are also widely sold on web stores—but that's a whole other conversation.

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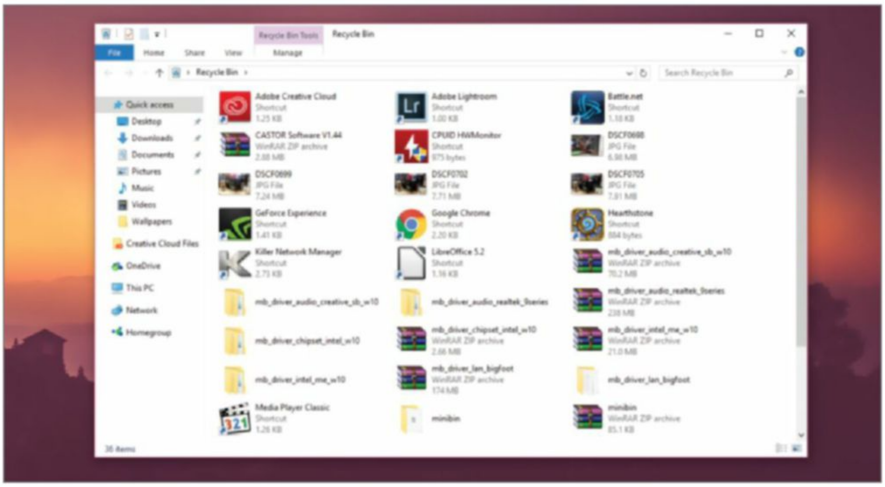
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH


Recycle Bin Tools
Recycle Bin
File
Home
Share
View
Manage
Recycle Bin
Search Recycle Bin
Quick access
Desktop
Downloads
Documents
Pictures
Music
Videos
Wallpapers
Creative Cloud Files
OneDrive
This PC
Network
Homegroup
Adobe Creative Cloud
Adobe Lightroom
Battle.net
CASTOR Software V1.44
CPUID HWMonitor
DSCF0698
DSCF0699
DSCF0702
DSCF0705
GeForce Experience
Google Chrome
Hearthstone
Killer Network Manager
LibreOffice 5.2
mb_driver_audio_creative_sb_w10
mb_driver_audio_realtek_9series
mb_driver_chipset_intel_w10
mb_driver_intel_me_w10
mb_driver_lan_bigfoot
Media Player Classic
minibin
36 items

HIDE YOUR RECYCLE BIN

After an icon-free desktop? Try a nifty piece of software called MiniBin, developed by e-sushi. You end up with a lovely little icon in your hidden icons bar that hotlinks out to your Recycle Bin. Just hide the desktop icon (type it into the Start menu), and you're all wrapped up. Point of advice: Once installed, right-click the icon, hit "Configure," and check the double-click action is set to "Open." Otherwise it empties on double-click.

MAKE – USE – CREATE

58
Control your Raspberry Pi with your voice

62
Increase your YouTube views the professional way

68
Build your own version of a Chromebook

ZAK STOREY
STAFF WRITER

COMBATING ANTIALIASING

I've wanted to talk about this for a while. I game at 4K, with a Fury X, at 60fps in most well-optimized AAA titles, without taking a hit on quality. That shouldn't be possible, right? The Fury X isn't a 4K-ready card. In theory.

It comes down to two things: antialiasing and pixel density. Antialiasing (AA) is a method of smoothing out what we call "jaggies" in rendering. Jaggies usually appear at the edges of objects in a scene, and detract from the overall experience. AA works to reduce these artefacts by various methods, but at the cost of graphical performance, with some forms of AA replicating the same pixel three or four times.

The thing is, jaggies are more noticeable at lower pixel densities—1080p and 1440p in particular. However, at 4K, a resolution that's four times higher than 1080p, it suddenly becomes less of an issue. For instance, a 27-inch 1080p panel has a pixel density of 81.59, a 1440p panel has a density of 108.79, and a 4K panel has 163.18. With that in mind, and with pixels twice as small as their 1080p counterparts, if you're careful with what AA settings you use, you can reduce the performance impact considerably, without any noticeable impact on overall graphical fidelity. Try it out. For those gaming at higher resolutions, you might gain an extra 20–30fps in some titles, and make 4K gaming a reality on a single card.

↘ submit your How To project idea to: comments@maximumpc.com

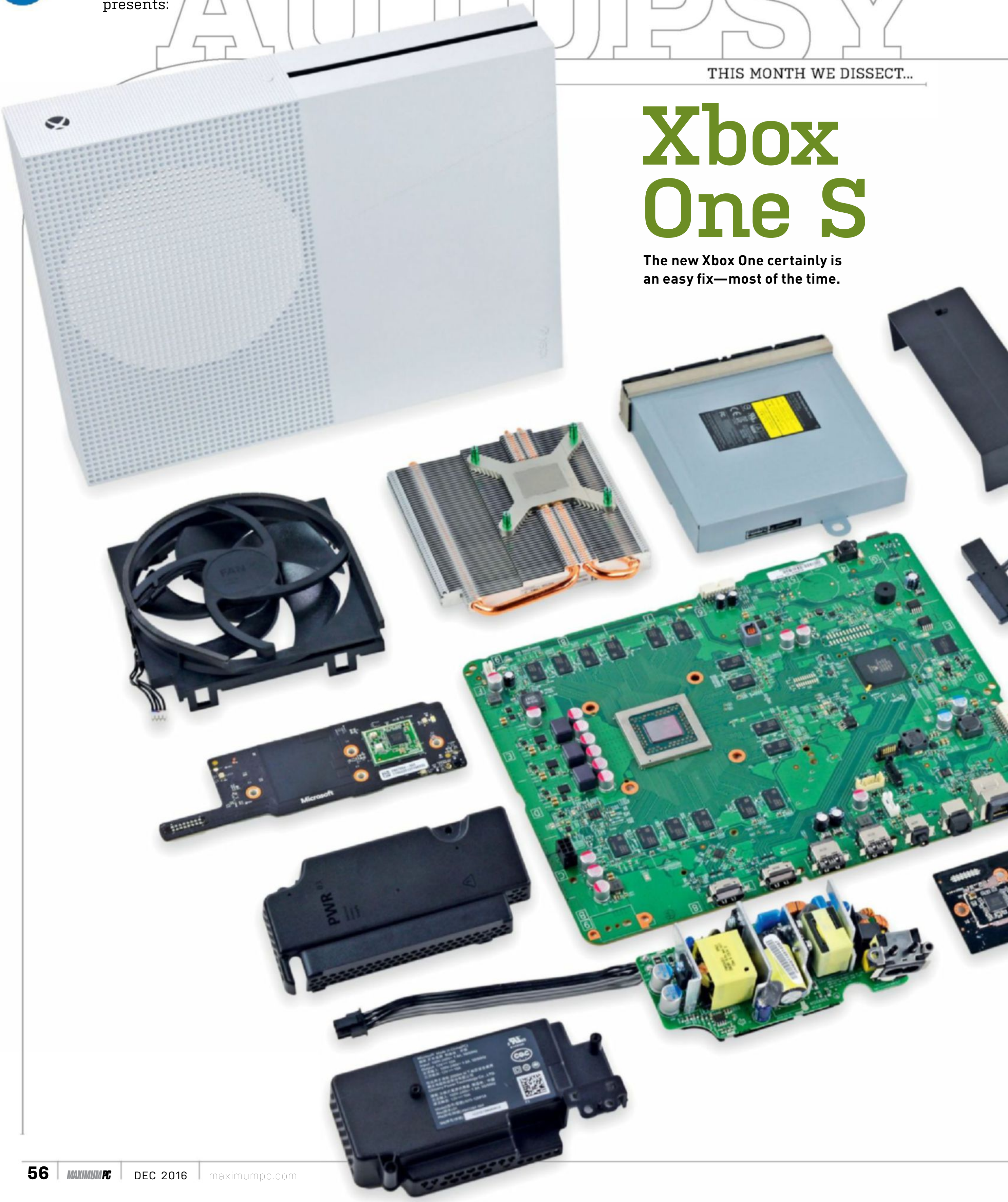
IFIXIT presents:

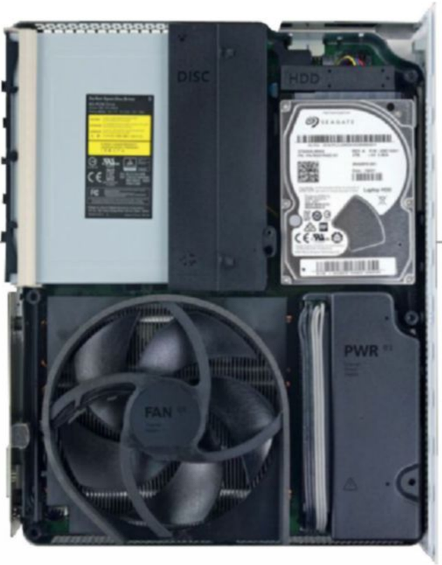
AUTOPSY

THIS MONTH WE DISSECT...

Xbox One S

The new Xbox One certainly is an easy fix—most of the time.





Well, that certainly makes things easy to identify.

Thankfully, Microsoft is still allowing users to swap out batteries in its controllers.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

BACKGROUND

Today, a new Xbox lands in our inbox, and that's a rare thing—though not as rare as it used to be. What makes the new Xbox One S a worthy mid-cycle update to Microsoft's console? Let's tear down this surprisingly slimmer, possibly speedier, appreciably sassier Xbox One, and find out. Game on!

MAJOR TECH SPECS

- Spec-bumped GPU supporting HDR10, along with the same AMD Jaguar eight-core SoC found in the original Xbox One.
- 2TB of storage (500GB and 1TB configurations are coming)
- HDMI 2.0a connectivity with support for 4K video at 60Hz
- Internal power supply
- IR blaster
- Fancy vertical stand (2TB model only)
- Redesigned Xbox Wireless Controller

KEY FINDINGS

- We take a moment to reminisce about our old Xbox 360 Opening Tool, but decide our trusty iFixit Opening Tool would be of more use. Make that Opening Tools—because popping that plastic "security" nub takes a little extra oomph. After some intense prying, we remove the bottom cover, revealing a metal interior case. These clips may be tough at first, but plastic is bound to bend or break, unlike a reusable screw. Next time you open your One S, it may not clip back together.
- Much like the RF board on the Xbox One, the front panel board of the Xbox One S detaches outward from the lower case. With the front panel board's EMI shield removed, we quickly spy a lone IC and some of its friends.
- Next up on the teardown chopping block is the Wi-Fi board. After removing a few Torx screws, it comes quietly, just like the front panel board before it. This is a nice incremental improvement over its location in the previous Xbox One—it makes for one less step to open the inner metal case. Wi-Fi is handled by a MediaTek MT7612UN (most likely a variation of the MT7612U 2x2 802.11ac Wi-Fi module).
- A springy, X-shaped bracket secures the heatsink to the motherboard—a signature part we've seen in every Xbox since the original 360. The "X" is a bit fussy, and takes some muscle, but some practiced prying with a flathead driver saves the day.
- Repairability Score: 8 out of 10 (10 is easiest to repair). Only a few tools are required to take the whole console apart. Once inside, a clean, no-nonsense modular design allows the drives, fan, heatsink, PSU, wireless board, and front daughterboard to be easily replaced. Fewer interlocking body panels and a simpler clip arrangement make opening this generation of Xbox easier than its senior. Replacing the hard drive will require both voiding your warranty and some difficult hackery to make it serviceable, though. ⏻

Control Your RPi With Your Voice

YOU'LL NEED THIS

RASPBERRY PI
See www.raspberrypi.org.

MICROPHONE
A USB model or a webcam with built-in mic.

IN *STAR TREK IV:* *The Voyage Home,* Scotty and Dr McCoy are offered the opportunity to use a computer, and are somewhat bemused when it fails to respond to voice commands. The film was made 30 years ago, and voice recognition has taken huge leaps forward since then. The Raspberry Pi has not been left out, and with the help of an inexpensive USB microphone [**Image A**] and some suitable software, you too can have your Pi search YouTube, open web pages, launch applications, and even respond to questions, simply by speaking.

The Pi has no built-in soundcard or audio jack, so you need a USB microphone or a webcam with built-in mic for this project. We tested the software using a Microsoft HD-3000 webcam, but any compatible device will do. Visit http://elinux.org/RPi_USB_Webcams for a full list of Pi-compatible webcams, but be sure that whatever device you choose has an integrated microphone. **–NATE DRAKE**

1

WHAT YOU NEED

If you only have a microphone with an audio jack, try searching Amazon or eBay for an inexpensive USB soundcard [**Image B**], which plugs into the USB port at one end, and has an output for earphones and a microphone at the other.

» There's a number of speech recognition programs available for the Raspberry Pi. For this project, we're using Steven Hickson's Pi AUI Suite, because it's powerful as well as extremely easy to set up and configure.

2

GETTING STARTED

Once you follow the steps in the walkthrough (see pg. 61), you will be able to start the installer. The Pi AUI Suite gives you a choice of a number of programs to install. The first question you are asked is whether it should install the dependencies. These, quite simply, are the files the Raspberry Pi needs to download for voice commands to work, so select "Y" and press Return to agree to this.

» Next, you are asked if you want to install the PlayVideo program, which enables you to use voice commands to launch and play video files. If you choose "Y," you're asked to specify the path to your media files—for example, "/home/pi/Videos." Note that upper-case letters are important here. If the path is invalid, the program warns you.

» You're then asked if you want to install the Downloader program, which searches for and automatically downloads files from the Internet for you. If you choose "Y" here, you're asked to provide settings for host, port, username, and password. If you aren't sure of these, press Return for now to choose the default options in each case. The following program is Google Text to Speech Service, which you may wish to install if you want the Pi to read out the content of text files. In order to use this service, the Raspberry Pi needs to be connected to the Internet, because it connects to Google's servers to "translate" the text into speech, and then plays an audio file with the Pi's media player.

» If you decide to install this, you need a Google account. The installer asks you to enter your username. Do so, then press Return. You're then prompted for your Google password. Enter this, and press Return again.

3

MORE SOFTWARE OPTIONS

The installer also offers you the chance to install Google Voice Commands. This uses Google's own speech recognition service. Again, you're asked to provide your Google username and password to continue. Whether or not you choose the Google-specific software, the program also asks whether you want to install the YouTube scripts. These tools enable you to speak a phrase such as "YouTube fluffy kittens," which then causes a relevant video clip to be played.

» Finally, the program gives you the option to install Voicecommand, which contains some of the more useful scripts, such as being able to launch your web browser by saying the word "Internet."

» The program asks you if you want Voicecommand to set itself up automatically. If you experience an error at this stage, follow Step 3 of the walkthrough (pg. 61).

4

TWEAK THE SETUP

Once the Voicecommand program is installed, you may wish to make a few basic changes to the setup before fine-tuning your configuration.

» Open Terminal on your Pi or connect via SSH and run the command `sudo voicecommand -s`.

» You are asked a series of yes/no questions next. The first question asks whether you want to permanently set the continuous flag. In plain English, the Voicecommand program is asking whether, each time you run it, you want it to continuously listen for your voice commands. Select "Y" for now. Next, you are asked whether you want the Voicecommand program to permanently set the verify

flag. Selecting "Y" here means the program expects you to say your keyword (by default, the word "Pi") before responding to your commands. This can be useful if you want to set the Raspberry Pi to listen continuously, and don't want it to act on everything you say out loud.

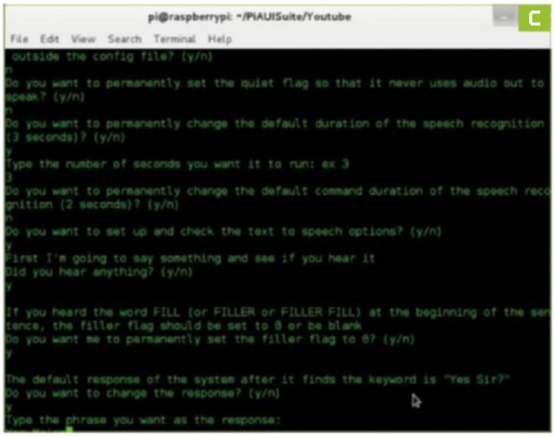
›› The following prompt asks if you want to permanently set the ignore flag. This means that if Voicecommand hears a command that's not specifically listed in your configuration file, it tries to look for a program in your installed applications and run it. For instance, if you say the word "leafpad," which is a notepad application, Voicecommand searches for and runs this even if not specifically told to.

›› We do not recommend you enable this feature. Because you're running Voicecommand as a SuperUser, there's too much risk that you could inadvertently tell the Pi a command that could harm your files. If you want to set up extra apps to work with Voicecommand, you can edit the configuration file in each specific case. (See "Voice Command Tweaks," over the page, for more information.)

›› Voicecommand then asks you whether you wish to permanently set the quiet flag, so it doesn't give a verbal response when you speak. Choose "Y" or "N" as you see fit.

5 MAKE YOUR PI TALK

Next, you're asked if you want to change the default duration for speech recognition. You should only change this if you're finding the Pi is having trouble hearing your commands. If you choose "Y," you're asked to type in a number—this is the number of seconds that the Pi listens for a voice command, and the default is 3. The program then gives you a chance to set up the text-to-speech options. Turn up your volume before doing this. The program attempts to say something, and asks whether you have heard it.


pi@raspberrypi: ~/PiAUISuite/Youtube
File Edit View Search Terminal Help
C

```
 outside the config file? (y/n)
n
Do you want to permanently set the quiet flag so that it never uses audio out to
speak? (y/n)
n
Do you want to permanently change the default duration of the speech recognition
(3 seconds)? (y/n)
y
Type the number of seconds you want it to run: ex 3
3
Do you want to permanently change the default command duration of the speech reco
gnition (2 seconds)? (y/n)
n
Do you want to set up and check the text to speech options? (y/n)
y
First I'm going to say something and see if you hear it
Did you hear anything? (y/n)
y

If you heard the word FILL (or FILLER or FILLER FILL) at the beginning of the sen
tence, the filler flag should be set to 0 or be blank
Do you want me to permanently set the filler flag to 0? (y/n)
y

The default response of the system after it finds the keyword is "Yes Sir?"
Do you want to change the response? (y/n)
y
Type the phrase you want as the response:
```

›› The default response of the system when responding to your keyword is "Yes sir?" Choose "Y" on the next prompt to change this, then type in your desired response, such as "Yes ma'am?" [Image C]. Press Return when you're done. The system plays back the response for you to confirm whether you're happy with the result.

›› The procedure is the same for the default message for when the system receives an unknown command. The default response is "Received improper command," but you can change this to something less robotic if you prefer, by typing "Y," then your chosen response—for example, "Unknown command."

6 TALK AWAY!

You are now offered the chance to set up the speech recognition options. This automatically checks whether you have a compatible microphone installed in your Raspberry Pi. Voicecommand next asks you whether you want the Pi to check your audio threshold for you. Make sure there is no background noise, press "Y," then hit Return.

›› It then asks you to speak a command to check that it has the correct audio device selected. The program automatically determines the right audio threshold for you, so type "Y" to choose this.

›› Finally, the Pi asks you if you want to change the default keyword ("Pi") to activate voice commands. Type "Y," then enter your new keyword. Press Return when

BASIC VOICE COMMANDS

Once installation of the Raspberry Pi AUI Suite is complete and you have run `sudo voicecommand -c` to set it to listen, you need to prime it with a keyword. By default, the keyword is "Pi," but feel free to alter this to something easier, such as the word "Jessie."

Next, you should try out a few of the built-in voice commands.

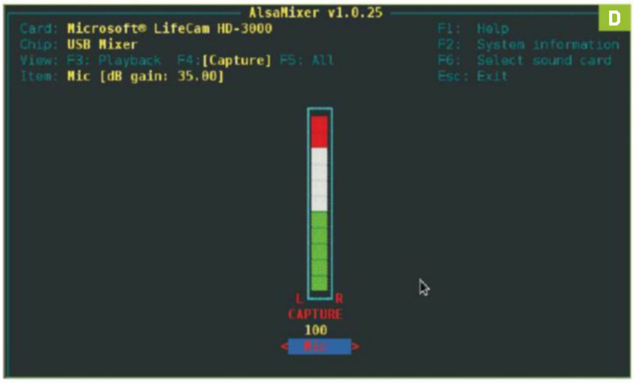
YOUTUBE: Saying "YouTube" and a video title automatically loads a full-screen video of the first relevant YouTube clip. This is similar to Google's "I'm feeling lucky." Say "YouTube" and the name of the video in which you're interested—for example, "YouTube fluffy kittens."

INTERNET: Saying the word "Internet" launches your web browser. By default, this is the Pi's built-in browser Midori, although you can change this.

DOWNLOAD: Saying the word "download" plus a search term automatically searches the Pirate Bay website for the file in question—for example, you could say "Download Ubuntu Yakkety Yak" to get the latest version of the Ubuntu Linux operating system.

PLAY: This command uses the built-in media player to play a music or video file—for example, "Play mozartconcert.mp4" would play that particular file located in the media folder you specified in setup, such as /home/pi/Videos.

SHOW ME: Saying "show me" opens up a folder of your choice. By default, the command doesn't go to a valid folder, so you need to edit your configuration file to a valid location—for example, `show me==/home/pi/Documents`.



D

```
AlsaMixer v1.0.25
Card: Microsoft® LifeCam HD-3000                    F1:  Help
Chip: USB Mixer                                     F2:  System information
View: F3: Playback  F4:[Capture] F5: All            F6:  Select sound card
Item: Mic [dB gain: 35.00]                          Esc: Exit
```

done. You are then asked to speak your keyword to acclimatize the Pi to your speaking voice. If this seems correct, type "Y" to complete the setup. Follow Step 6 of the tutorial opposite to run the Voicecommand software. Try to start out with a few simple commands. (See "Basic Voice Commands," on the previous page, for more information.) Once you're comfortable with these, run the command `sudo killall voicecommand` to shut down the program, and edit your configuration file if you wish.

7 VEXING VOICES

Voice recognition software is a work in progress, and the Pi may not recognize everything you say. To improve your chances, be sure to stay near the USB microphone, and speak slowly and clearly.

» If you're still having trouble being understood, open Terminal on your Pi or connect via SSH and run the command `alsamixer` to open your sound settings. Press F4 to choose audio input, then press F6. Use the arrow keys to select your USB device, then press Return. This controls the volume of your USB microphone. Use the up arrow to push it to maximum (100) [**Image D**].

» If your USB microphone isn't being detected at all, it might need more power than the Raspberry Pi's USB ports can provide on their own. The best solution to get round this is to use a powered USB hub. The Pi Supply website sells a seven-port powered hub for just $13 (http://bit.ly/2c8H10y). A powered USB hub can also be useful if you want to use an external hard drive with your Raspberry Pi.

8 TROUBLESHOOTING TIPS

Once the Download program is installed, if you experience an error connecting, bear in mind that access to the PirateBay website may be restricted where you are. In order to download files, you also need a BitTorrent client for the Pi, such as the program Transmission. You can install this by opening Terminal or connecting to your Pi over SSH and running the command `sudo apt-get install transmission`. Help with getting started and how to use the client is available from the Transmission website at https://forum.transmissionbt.com. Needless to say, you should only download files with the permission of the copyright holder.

» If you choose to use Google Voice Commands or Google TTS (Text to Speech), bear in mind that anything you say and any text files you submit are sent to Google's servers for translation. Google claims not to retain any of this data, but even if it is to be believed, any data transmitted over the Internet can potentially be intercepted by a third party. Google does encrypt your connection to reduce the chance of this happening, however.

» If you find you're happy with the voice command feature, you might prefer the software to start automatically each time you boot the Pi. If so, open Terminal on your Pi or connect via SSH and run the following command:

```
nsudo nano /etc/rc.local
```

» This opens the file that determines which processes start up when your Raspberry Pi boots. By default, this script does nothing. Use your arrow keys to scroll to the bottom of the file and, just above the line reading `exit 0`, type the following:

```
sudo voicecommand -c
```

» Press Ctrl-X, then Y, then Return to save your changes. Feel free to reboot the Pi at this stage to make sure it works. If you're unsure whether Voicecommand is running, open Terminal and run the command `ps -a` to show a list of running processes. ⏻

VOICE COMMAND TWEAKS

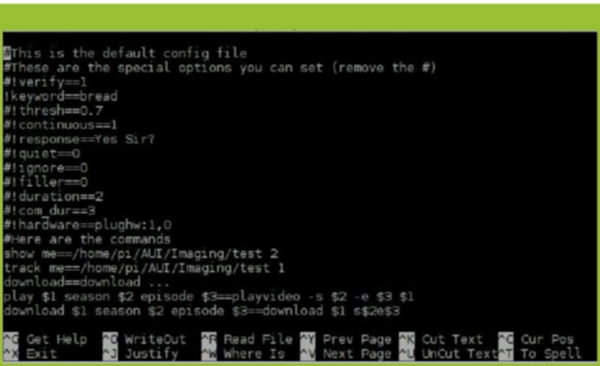
Once your Voicecommand software is up and running, you can edit the configuration file to add new commands or modify existing ones.

Run the command `sudo nano /root/.commands.conf` to view the configuration file. As you'll see, most of the lines begin with a `#` symbol, which means the Pi ignores them. Delete the symbol to activate the line. If, for instance, you want to change the keyword that activates the voice recognition software from "Pi" to "Jessie," you would change the line from `#!keyword==pi` to `-!keyword=jessie`.

If you use the Firefox web browser instead of Midori on your Raspberry Pi, you may also want to change `~Internet==midori &` to `~Internet==firefox-esr &`.

The software can run any command. For instance, to open the desktop by saying the word "desktop," add the following line to the end of the file: `desktop==home/pi/Desktop`. You can also launch programs as you would from the terminal—for example, `notepad==leafpad`.

As you're talking to your Raspberry Pi, you may want it to respond to you with speech. Do this first by opening Terminal



```
#This is the default config file
#These are the special options you can set (remove the #)
#!verify==1
!keyword==bread
#!thresh==0.7
#!continuous==1
#!response==Yes Sir?
#!quiet==0
#!ignore==0
#!filler==0
#!duration==2
#!com_dur==3
#!hardware==plughw:1,0
#Here are the commands
show me==/home/pi/AUI/Imaging/test 2
track me==/home/pi/AUI/Imaging/test 1
download==download ...
play $1 season $2 episode $3==playvideo -s $2 -e $3 $1
download $1 season $2 episode $3==download $1 s$2e$3

^G Get Help   ^O WriteOut   ^R Read File  ^Y Prev Page  ^K Cut Text   ^C Cur Pos
^X Exit       ^J Justify    ^W Where Is   ^V Next Page  ^U UnCut Text ^T To Spell
```

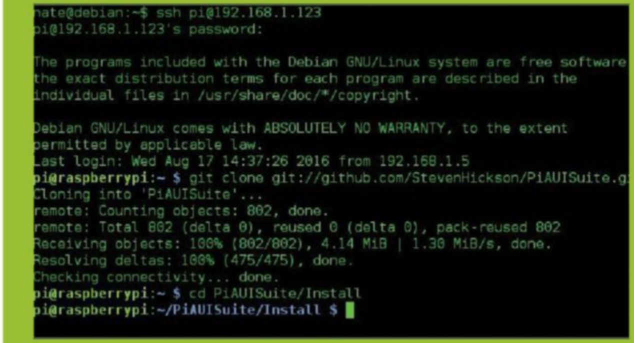
and installing the speech synthesis software Festival with the following command:

```
sudo apt-get install festival
```

The basic format to get the Raspberry Pi to talk is `echo "Your message here" | festival –tts`. You can also have the Pi read out system information. For example, if you wanted the Pi to tell you the date and time, you would need to add the following line to the config file:

```
time==echo "The time is" | festival --tts && date | festival –tts
```

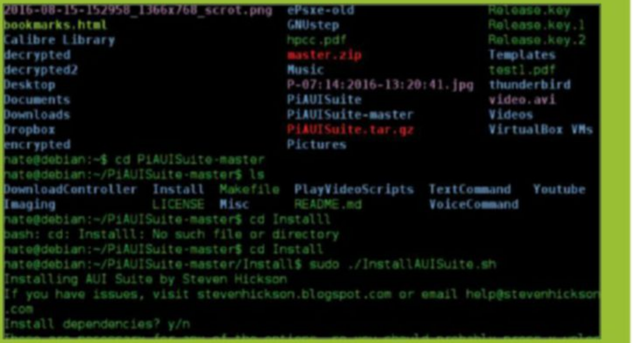
SET UP VOICE COMMANDS ON YOUR PI



```
nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:

The programs included with the Debian GNU/Linux system are free software
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:37:26 2016 from 192.168.1.5
pi@raspberrypi:~ $ git clone git://github.com/StevenHickson/PiAUISuite.g
Cloning into 'PiAUISuite'...
remote: Counting objects: 802, done.
remote: Total 802 (delta 0), reused 0 (delta 0), pack-reused 802
Receiving objects: 100% (802/802), 4.14 MiB | 1.30 MiB/s, done.
Resolving deltas: 100% (475/475), done.
Checking connectivity... done.
pi@raspberrypi:~ $ cd PiAUISuite/Install
pi@raspberrypi:~/PiAUISuite/Install $
```

1. DOWNLOAD INSTALLATION FILES

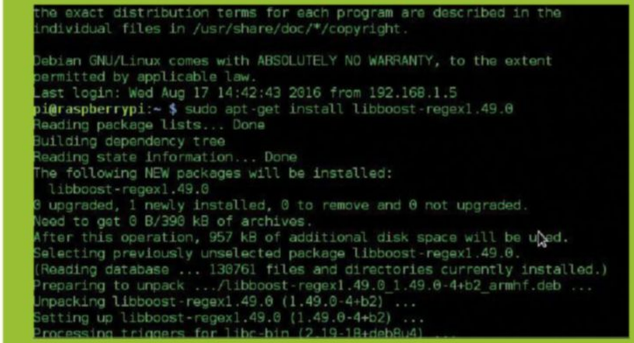
Open Terminal on your Raspberry Pi or connect via SSH and download the installation files by running the command `git clone git: //github.com/StevenHickson/PiAUISuite.git`. When the download is complete run `cd PiAUISuite/Install` to open the installation directory.



```
2016-08-15-152958_1366x768_scrot.png  ePsxe-old                     Release.key
bookmarks.html                        GNUstep                       Release.key.1
Calibre Library                       hpcc.pdf                      Release.key.2
decrypted                             master.zip                    Templates
decrypted2                            Music                         test1.pdf
Desktop                               P-07:14:2016-13:20:41.jpg     thunderbird
Documents                             PiAUISuite                    video.avi
Downloads                             PiAUISuite-master             Videos
Dropbox                               PiAUISuite.tar.gz             VirtualBox VMs
encrypted                             Pictures
nate@debian:~$ cd PiAUISuite-master
nate@debian:~/PiAUISuite-master$ ls
DownloadController  Install  Makefile  PlayVideoScripts  TextCommand   Youtube
Imaging             LICENSE  Misc      README.md         VoiceCommand
nate@debian:~/PiAUISuite-master$ cd Installl
bash: cd: Installl: No such file or directory
nate@debian:~/PiAUISuite-master$ cd Install
nate@debian:~/PiAUISuite-master/Install$ sudo ./InstallAUISuite.sh
Installing AUI Suite by Steven Hickson
If you have issues, visit stevenhickson.blogspot.com or email help@stevenhickson
.com
Install dependencies? y/n
```

2. RUN THE INSTALLER

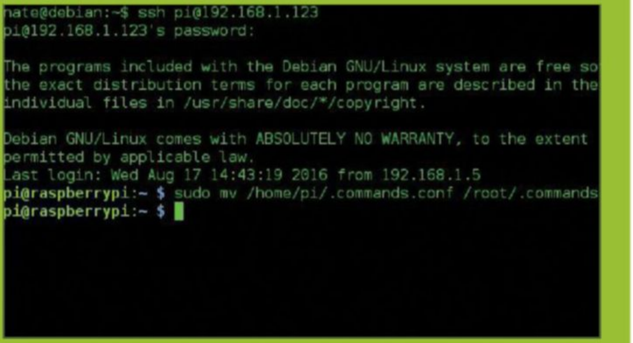
Use the command `sudo ./InstallAUISuite.sh` to run the text installer. Choose `y` to install any dependencies, and then work your way through the installation wizard. See the main article for more details about how to do this.



```
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:42:43 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo apt-get install libboost-regex1.49.0
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  libboost-regex1.49.0
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/390 kB of archives.
After this operation, 957 kB of additional disk space will be used.
Selecting previously unselected package libboost-regex1.49.0.
(Reading database ... 130761 files and directories currently installed.)
Preparing to unpack .../libboost-regex1.49.0_1.49.0-4+b2_armhf.deb ...
Unpacking libboost-regex1.49.0 (1.49.0-4+b2) ...
Setting up libboost-regex1.49.0 (1.49.0-4+b2) ...
Processing triggers for libc-bin (2.19-18+deb8u4) ...
```

3. INSTALL BOOST C++ LIBRARY

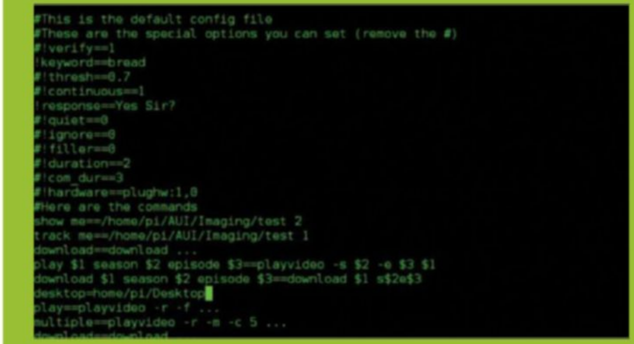
If you encounter an error when trying to set up the Voicecommand program, run `sudo apt-get install libboost-regex1.49.0` to install the necessary software. Next, run `sudo ./InstallAUISuite.sh` to run the installer again.



```
nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:

The programs included with the Debian GNU/Linux system are free so
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:43:19 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo mv /home/pi/.commands.conf /root/.commands
pi@raspberrypi:~ $
```

4. COPY CONFIGURATION FILES

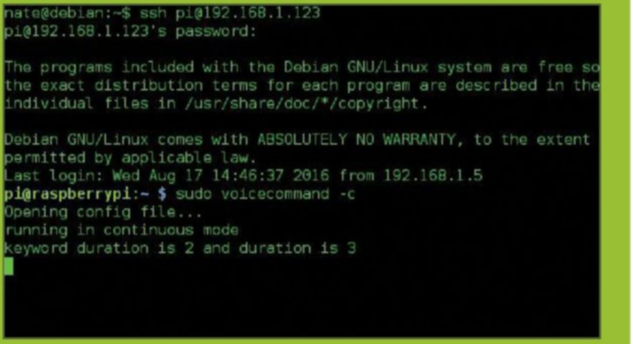
Because you're going to be running the Voicecommand program as the root user, you need to use the command `sudo mv /home/pi/.commands.conf /root/.commands.conf` to copy across the necessary configuration files.



```
#This is the default config file
#These are the special options you can set (remove the #)
#!verify==1
!keyword==bread
#!thresh==0.7
#!continuous==1
!response==Yes Sir?
#!quiet==0
#!ignore==0
#!filler==0
#!duration==2
#!com_dur==3
#!hardware==plughw:1,0
#Here are the commands
show me==/home/pi/AUI/Imaging/test 2
track me==/home/pi/AUI/Imaging/test 1
download==download ...
play $1 season $2 episode $3==playvideo -s $2 -e $3 $1
download $1 season $2 episode $3==download $1 s$2e$3
desktop=home/pi/Desktop
play==playvideo -r -f ...
multiple==playvideo -r -m -c 5 ...
```

5. EDIT CONFIG FILE

Use the command `sudo nano /root/.commands.conf` to inspect your configuration file. You can now change your keyword or add extra commands. (See "Voice Command Tweaks," opposite, for more information.)



```
nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:

The programs included with the Debian GNU/Linux system are free so
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:46:37 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo voicecommand -c
Opening config file...
running in continuous mode
keyword duration is 2 and duration is 3
```

6. RUN VOICECOMMAND

Use the command `sudo voicecommand -c` to start the software. It automatically listens out for your keyword. You can then give it further commands, such as "YouTube fluffy kittens."

Increase YouTube Views the Pro Way

YOU'LL NEED THIS

A GOOGLE ACCOUNT

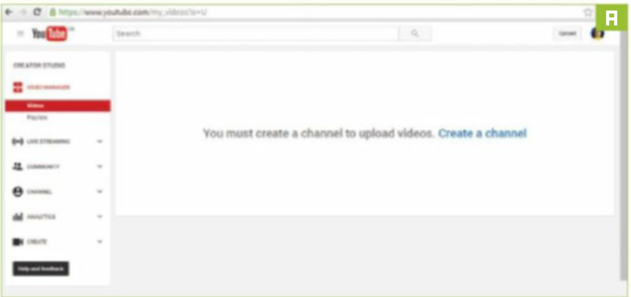
Creating a YouTube channel is straightforward and free, as long as you're logged in to Google.

EDITING TOOLS

Video and image editors are essential—don't rely on YouTube's gimmicks.

YOUTUBE IS A TRICKSY BEAST, as much a video-hosting website as it is a mysterious, unfathomable, and ever-changing algorithm. Getting your content seen initially is a massive crapshoot. There's a vague chance that you'll roll a seven, and pick up a huge amount of traffic, but those dice are weighted heavily toward snake eyes. The best you can hope for in real terms is to make your videos as interactive and fully-featured as possible.

Here we'll lead you through using YouTube's own back-end tools to add links, references to your other content, and quality enhancements to make the experience pleasant for your viewers, as well as covering a few ways to weight the algorithm in your favor. Like many Google projects, YouTube has introduced these tools piecemeal over time—there's no great synergy between them, so there's a fair amount to learn. But do it right, and you'll see a marked increase in viewers. –**ALEX COX**



You must create a channel to upload videos. Create a channel

1 VIDEO DEVELOPMENT

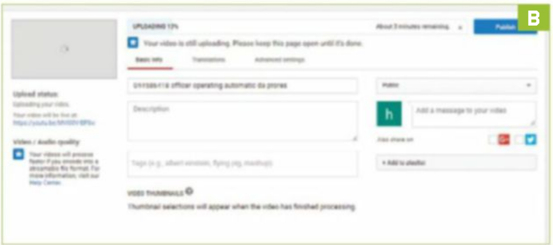
Hold your horses, hotshot. Before approaching YouTube's tools, you need to start thinking along the right lines when creating your videos. If you ever refer to something from one of your previous uploads during a recording, make a note somewhere, as you'll be adding a link to it later. Ensure you include a graphic with a subscribe icon in your video somewhere. Consider creating an end card, with footage of other episodes you've uploaded, to encourage viewers to enjoy more of your stuff. Or, if you're running a series, think about including a little of the next episode as a teaser. These are all small things, but they're important ways to grab that audience.

›› Think about the video thumbnail. This is your key tool to drag viewers in to your channel, and it's far more important than any clickbait video title. Yes, there are people who've made a massive impact on YouTube without custom thumbnails, but they're few and far between, and you're probably not going to be one of them. Make sure thumbnails are eye-catching, exciting, and of a professional standard. Get your branding right, and the rest will follow.

2 INITIAL UPLOAD

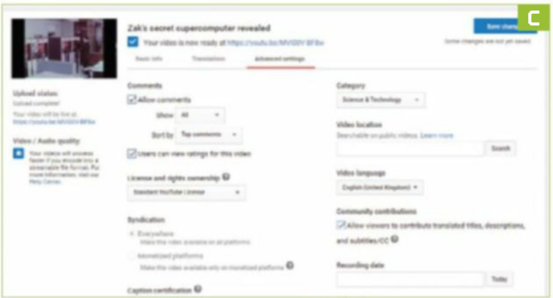
With your video and associated resources ready, head over to YouTube. Log in with your Google account, click your circular avatar, and head to the Creator Studio. If you don't already have a YouTube channel, you'll see a gigantic button encouraging you to create one [**Image A**]; make sure you click "Use a business or other name," unless you want everything uploaded under your real name. Head to the "Channel" tab when you're done, and hit the blue "Verify"button to go through the process of verifying your account; you're subject to certain restrictions until you do.

›› There's an "Upload" button just to the right of the search box; click it, then drag your video on to the appropriate area, making sure you set the privacy away from "Public," unless you want all and sundry to see your creation before it's finished. While your video uploads and gets processed through YouTube's coal-fired steam computer [**Image B**], you can begin filling in the early key information. Give it a catchy title, fill in the description with as much detail as you can—you're looking for decent search traffic, after all—and go to town on the tags field, adding as many appropriate words and phrases as come to mind. When YouTube looks to include your stuff in "related videos" lists, it's assumed that it looks here first—nobody knows for sure, and it could all change tomorrow—so imagine the sort of tags your friends or rivals are using, and include them here.



3 MORE SETTINGS

Before you've finished with the initial upload stage, head over to the "Advanced Settings" tab [**Image C**]. You can do things here such as blocking comments and setting the license for your video—useful if you're happy for it to be remixed by Creative Commons users. Things we'd deem as non-optional are setting a category for your video,



Zak's secret supercomputer revealed

Comments

☑ Allow comments

Show All

Sort by Top comments

☑ Users can view ratings for this video

License and rights ownership

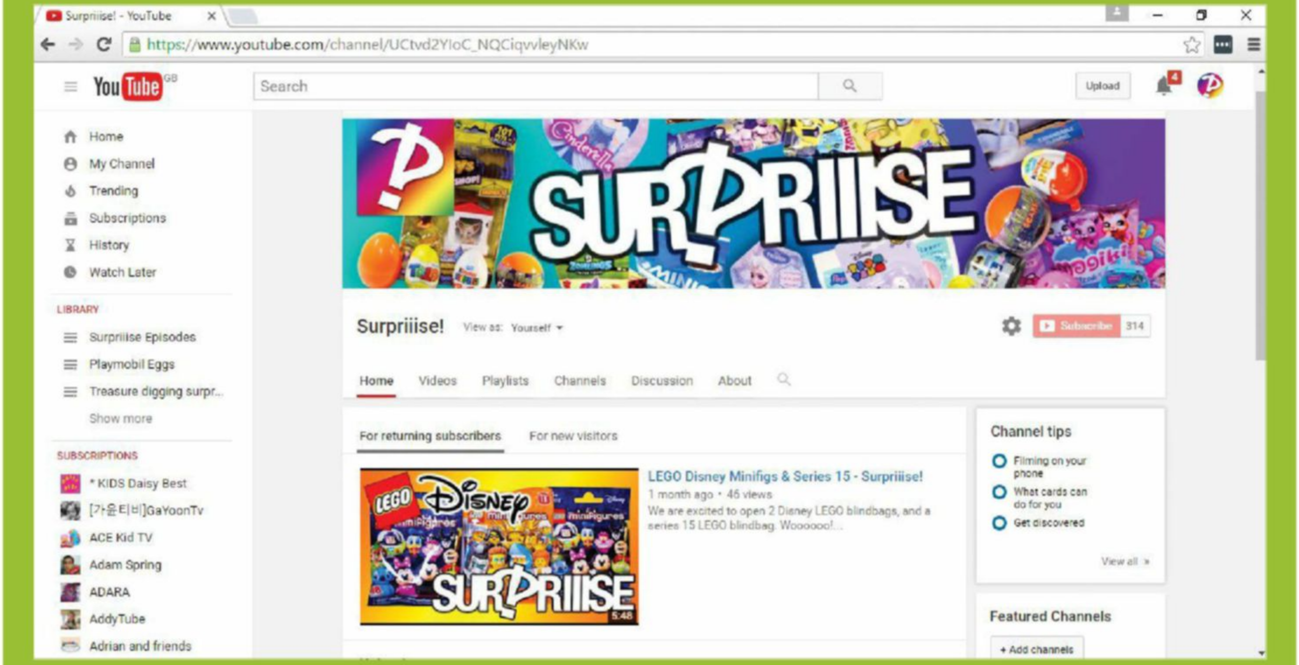
Standard YouTube License

Category

Science & Technology

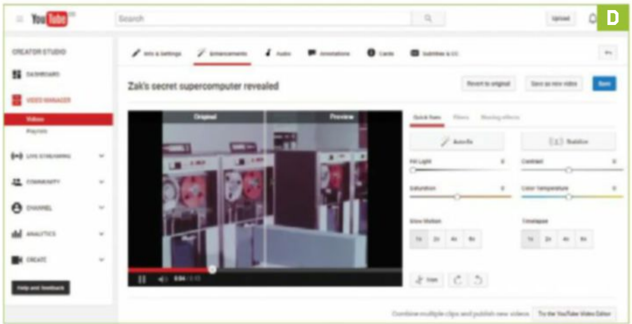
Caption certification

PRESENT AND CORRECT


Surpriiise! - YouTube
https://www.youtube.com/channel/UCtvd2YIoC_NQCiqvleyNKw
YouTube GB
Search
Upload
Home
My Channel
Trending
Subscriptions
History
Watch Later
LIBRARY
Surpriiise Episodes
Playmobil Eggs
Treasure digging surpr...
Show more
SUBSCRIPTIONS
* KIDS Daisy Best
[가온티비]GaYoonTv
ACE Kid TV
Adam Spring
ADARA
AddyTube
Adrian and friends
SURPRIISE
Surpriiise!
View as: Yourself
Subscribe 314
Home
Videos
Playlists
Channels
Discussion
About
For returning subscribers
For new visitors
LEGO Disney Minifigs & Series 15 - Surpriiise!
1 month ago • 46 views
We are excited to open 2 Disney LEGO blindbags, and a series 15 LEGO blindbag. Woooooo!...
5:48
Channel tips
Filming on your phone
What cards can do for you
Get discovered
View all
Featured Channels
+ Add channels

The presentation of your channel is super-important. It's what separates the lowly amateurs from the YouTube pros; new viewers stumbling upon a great-looking channel are more likely to check out the content within. The first thing they see is your channel's icon; head to "Channel → Advanced" to set it to something beautiful, and input the keywords you'd like associated with your channel. Then head to your channel, and hover your cursor over the banner at the top—click the pen icon, then "Edit channel art" to upload a beautiful header image of your own. There's a template at https://support.google.com/youtube/answer/2972003?hl=en-GB to help you get the proportions right.

One thing that's worth considering, at least if you have more esoteric output, is creating a channel trailer to introduce new visitors to your wares. Upload it as usual, head to your channel, click "For new visitors," then use the plus button to select the video you want to appear on top of your uploads.


D
Zak's secret supercomputer revealed
Original
Preview

selecting its language, and allowing community contributions, which means your content can be subtitled in foreign languages by willing volunteer viewers. And absolutely ensure that you click the content declaration if you've been paid to feature a particular product—not doing so could land you in a world of legal hurt.

» Click "Done" when you're, er, done—you don't need to wait for the video to finish processing, but do ensure you wait for the upload to complete.

4

THE REAL MEAT

Head back to the Creator Studio and click "Edit" on the video you just uploaded. You'll see many of the same options as before, but lots more are now listed on the top bar. Let's start where we are, though; this first screen should give you a button with which you can upload your own thumbnail image. Make sure it's in 16:9 format and under 2MB—you may have to use a compressed JPEG rather than a PNG, given the file size restrictions, and we tend to scale ours to at least 1920x1080. Alternatively, if you like to live dangerously, you can use one of YouTube's three pulled-out images, but these are likely to be rubbish. When you're happy, click "Save Changes," then head to the "Enhancements" tab.

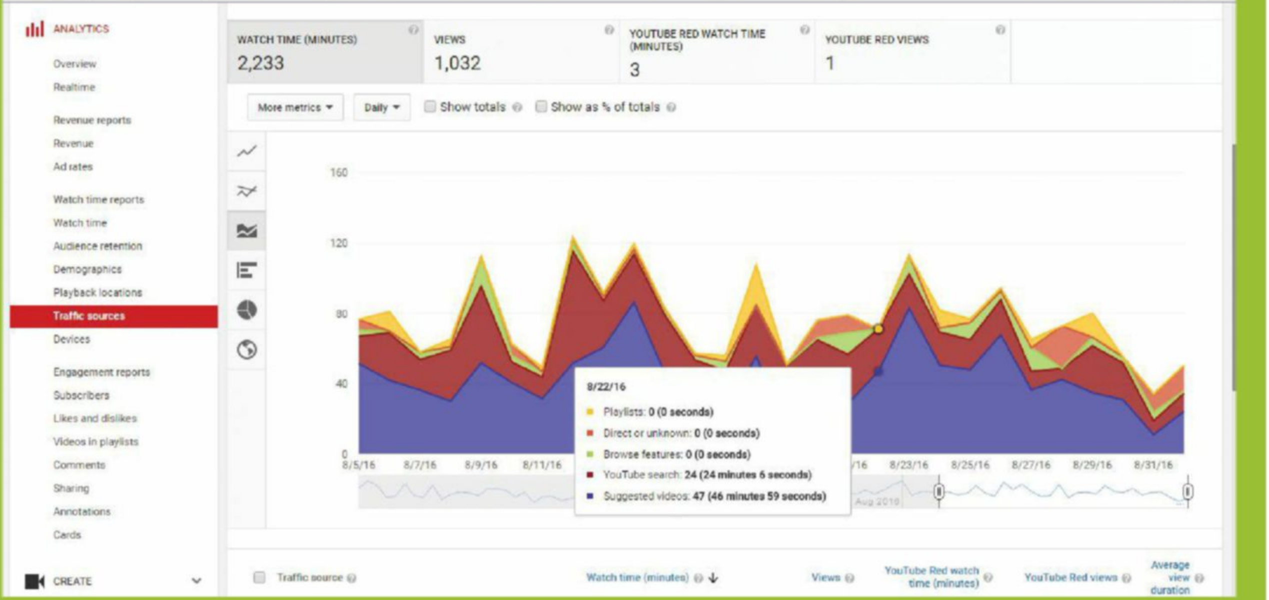
5

ZOOM, ENHANCE

There are various silly tools on the "Enhancements" tab that you should never, ever touch, such as slow motion, time lapse, and stabilize. Leave them alone—if you're after that sort of effect, do it in your editing software before uploading. Clicking the "Auto-fix" button can have beneficial effects for muddy videos; give it a go, and you'll be able to view a side-by-side before and after preview of your video [Image D]. Drag the center line to change how much of each is displayed.

» Hit the "Trim" button to make sure the start and end points of your upload are properly set. The "Filters" panel offers up a host of oh-so-hip video filters that will probably just annoy your audience, and the "Blurring effects" panel offers up the only-slightly-useful option of automatically blurring out faces using Google's tried and tested anonymity filter. Click "Save" when you're done. Alternatively, you can save the results to a new video if

SEEING THE IMPACT


ANALYTICS
Overview
Realtime
Revenue reports
Revenue
Ad rates
Watch time reports
Watch time
Audience retention
Demographics
Playback locations
Traffic sources
Devices
Engagement reports
Subscribers
Likes and dislikes
Videos in playlists
Comments
Sharing
Annotations
Cards
CREATE
More metrics
Daily
Show totals
Show as % of totals
160
120
80
40
0
8/5/16
8/7/16
8/9/16
8/11/16
8/23/16
8/25/16
8/27/16
8/29/16
8/31/16
Aug 2016
Traffic source
Watch time (minutes)
Views
YouTube Red watch time (minutes)
YouTube Red views
Average view duration

WATCH TIME (MINUTES) 2,233

VIEWS 1,032

YOUTUBE RED WATCH TIME (MINUTES) 3

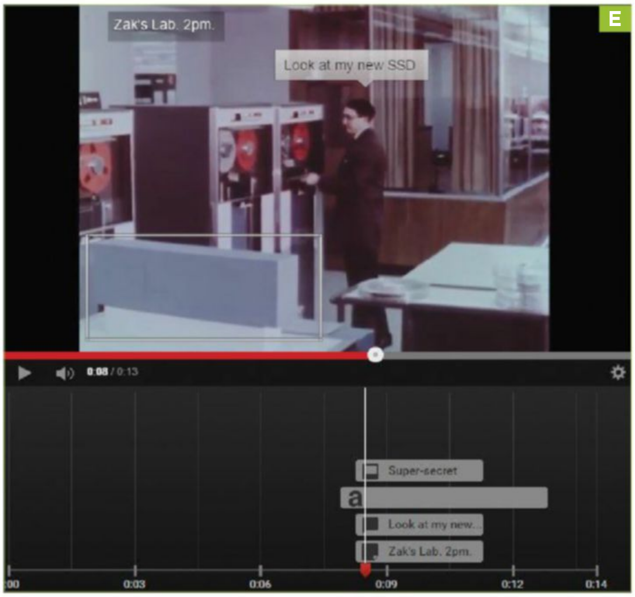
YOUTUBE RED VIEWS 1

8/22/16
- Playlists: 0 (0 seconds)
- Direct or unknown: 0 (0 seconds)
- Browse features: 0 (0 seconds)
- YouTube search: 24 (24 minutes 6 seconds)
- Suggested videos: 47 (46 minutes 59 seconds)

YouTube's analytics tools are a brilliant way to track the impact of your changes on your viewership, and see how much you're raking in from those lovely pre-roll ads. Head to the "Analytics" section on the left to see an overview of your channel's action over the last 28 days, or click "Realtime" for recent activity.

"Audience retention" is relevant if you're concerned about the impact of your videos; if people tune out after a few seconds, you're probably doing something wrong. YouTube won't tell you what, of course, but low audience retention is a good indication that changes are required. Once you've kitted up your vids with annotations and cards, check the relevant sections at the bottom to see how often your viewers interact with them. Don't dump them altogether, but perhaps tweak your approach.

Finally, keep an eye on "Traffic Sources," to get a handle on where your viewers are coming from; if your social media wrangling is going well, you'll know it here.


E
Zak's Lab, 2pm.
Look at my new SSD
0:08 / 0:13
Super-secret
a
Look at my new...
Zak's Lab, 2pm.
00
0:03
0:06
0:09
0:12
0:14

you don't want your original spoiled, or click "Revert to original" if you've made a real mess.

6 SUPER SOUNDTRACK

The last thing you want, if you're a YouTube content creator, is a copyright strike. One of the best ways to get one—or at least have a third party take your ad revenue for themselves—is using audio to which you don't own the rights. The "Audio" tab gives you access to the YouTube audio library, and provides you with a quick way to slap that music directly on top of your video, but (like so many of these tools) it's clumsy at best. Pick your track, hit the "Position Audio" button, and you can trim and move your track, so that it appears exactly where you want it.

›› You may be better served accessing the audio library at the initial editing stage. Head to www.youtube.com/audiolibrary/music to find it—everything here can be used without issues to add a little audible flash to your videos. Bear in mind, though, that you may be required to include some specific waffle in your video description if you do use certain tracks—check the license before you decide to download the file.

7 ANNOTATE AND ELUCIDATE

Annotations, in the next tab, can serve several purposes. For instance, you can use them to issue corrections to elements of your videos, if you find out there's a mistake after uploading—because there's no way to replace a video once it's gone up (other than removing it and then making a new upload, which destroys any comments and viewing figures), it can often be beneficial to place a big placard of culpability over the top of the offending scene. Also, many people put annotations to use by adding vastly annoying notes and plugs, which is a good way to get your viewers to switch annotations off completely. The third, most critical use, is adding links to your videos, adding interactivity to your "Subscribe" button, or linking users to other videos that you may have produced.

›› Annotations come in five different varieties: translucent speech bubbles, notes (also translucent, like a speech bubble without the tail), transparent-backed titles, labels, which display text when viewers hover their mouse pointer over the top, and spotlights, which are basically just rectangles. Select them from the "Add annotation" drop-down, and they're added to the video at the current time—use the anchor points around them to position them exactly where you'd like them on the video. You can then drag their edges in the timeline below the video preview [**Image E**], or use the start and end boxes in the right column, to make them last longer or shorter, drag their meaty middles to make them appear at precisely the right time, and use the appropriate boxes to fill them with text, and change font colors or sizes. All types except for the title can be made clickable by checking the "link" box at the bottom of the right column—usually, content creators use spotlight boxes to add links, because they don't cover up the video behind, but your mileage may vary.

8

CARD COUNTING

Annotations are brilliant for giving desktop users additional interactivity, but they're useless if your audience is on a mobile device. That's useless as in completely, absolutely, utterly useless. They don't display at all, at least at press time, and they never have. You need to add any appropriate links to your description, so that mobile users can follow them. Put explicit instructions to click those links in the video itself—don't assume all viewers are idiots, but equally don't assume that they're not—and ensure you make use of the one interactive element that does work for mobile users: cards. Frequently ignored, these little drop-in white boxes are quick to add, irritate viewers less than annotations, and are actually pretty effective at pushing traffic around. Head to the appropriate tab to start adding them.

›› Cards come in four distinct varieties. With the first option, you can link directly to one of your existing videos or playlists, or to a video or playlist from another channel by copying the URL and pasting it in the appropriate text box. Use the drop-down box at the bottom of the window to customize what the card says, then hit "Create Card" to add it. The second option offers up specific promotion of a friendly channel—great for collaborations, or backing up any mention you might have made. The third enables you to create polls, which you can check later by navigating to the appropriate point in your video. The final one enables you to create an annoyingly restrictive link, either to a specific site associated with your account, or to one of YouTube's list of approved retailers or crowdfunding sites.

›› Add a card and you'll see it appear to the right of the preview window, with a note saying you've used one of your allocated five cards, and a draggable marker appears on the timeline below. Note that you can only adjust its position, not its duration—cards automatically stay active for 10 seconds, then get out of the way.

9

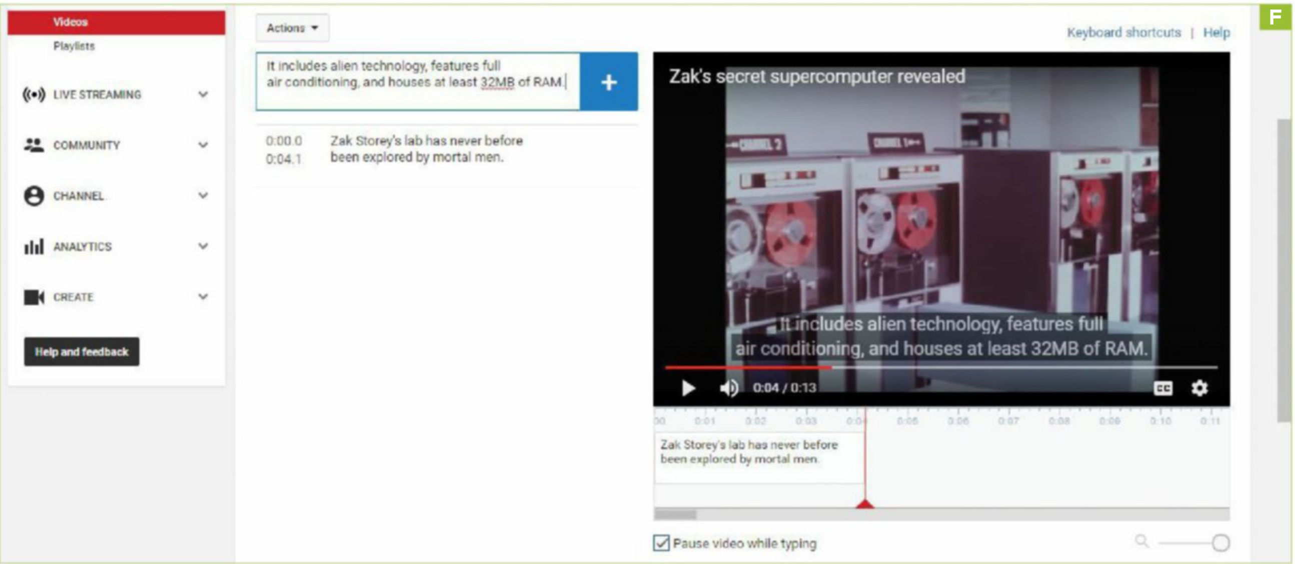
CAPTION CONTEST

YouTube does have its own automatic subtitling engine [**Image F**], which ranges in effectiveness from so brilliant it might as well be magic to hilariously bad. It's fine to rely on it, but your audience—particularly if they're watching without audio, or if your soundtrack is a little garbled or backed by music—deserves better. The "Subtitles and CC" tab enables you to add your own accurate captions, either from a text transcript or by typing them as you watch the video. The latter option works well; hit "Play" on the preview window, then start typing as soon as you hear the first line. The video pauses automatically, and you see your caption start to appear. If you want to add a line break, just hit Shift-Return, and click the blue plus icon when you're happy. You can drag captions in the timeline below the preview to adjust their length and position, and add as many as you need. Your changes are automatically saved as a draft, so hit "Publish" when you're done and ready for your captions to go live.

10

FINISHING TOUCHES

The idea is to get eyes on your content, so there's a few more things you can do. Organize your videos into playlists, for a start, which helps YouTube send your viewers to the next episode, once the current one is complete, and enables viewers to easily binge on curated content lists. Collaborate with other video creators to get your name out there. Post your stuff to social media. Reply to comments, however asinine they may be, so your audience feels connected. It's hard work, but it'll be worth it in the end. ⏻


F

It includes alien technology, features full
air conditioning, and houses at least 32MB of RAM.

0:00.0 0:04.1 Zak Storey's lab has never before been explored by mortal men.

Zak's secret supercomputer revealed

It includes alien technology, features full
air conditioning, and houses at least 32MB of RAM.

Zak Storey's lab has never before been explored by mortal men.

☑ Pause video while typing

Recreate the Prisma Look

YOU'LL NEED THIS

PHOTOSHOP
Subscribe at www.adobe.com.

A SUITABLE IMAGE
Choose something with strong colors and good contrast.

FILTERING APP PRISMA has become very popular among smartphone warriors. This Russian-made app—which, until a recent update moved some computing to your phone's processor, would shunt your photo to its servers for a thorough going-over by a neural network, and even an AI—recreates photos with a textured oil-painting look, among other tricks.

It's still filtering, though, so the result is out of your control, other than fading it out if it's been applied so strongly you can't recognize the original subject. With a PC, we are in control, and can apply it to selected areas, and make artworks that aren't square—a major drawback of the app.

We're going to use Photoshop's Filter menu, building an effect out of layers. And while we've used Photoshop CC, there's nothing to stop you using Photoshop Elements or GIMP. –IAN EVENDEN

1 SELECT AN IMAGE

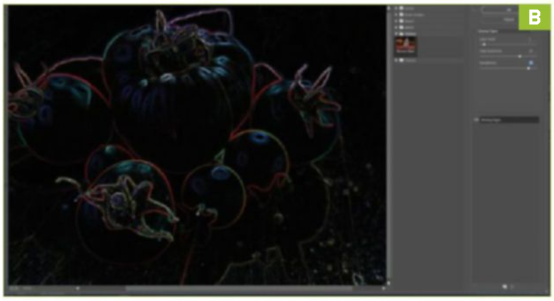
Firstly, your choice of image is important [Image A]. We're looking for something with strong colors, and some decent contrast between subject and background. We've chosen these tomatoes partly for these reasons, and partly because we grew them ourselves and want to show them off. Open your image in Photoshop, then duplicate the Background layer, so you've got a new, identical one floating on top of it.

2 FADE TO BLACK

We need some darkness around the edges of our tomatoes. There are several ways you could do this, including using the Pen tool to draw a path around the edges and coloring it black with a Stroke, but we're going to use Photoshop's ability to find the edges in a photo. From the "Filter" menu, pick "Filter Gallery," and head down to "Stylize," then "Glowing Edges." We're doing this because it makes the background black. Slide the "Edge Brightness" and "Smoothness" sliders to the right, but keep the "Edge Width" to the left [Image B]. The effect you want is smooth black punctuated by obvious edges in bright colors. Hit "OK" when you're happy.

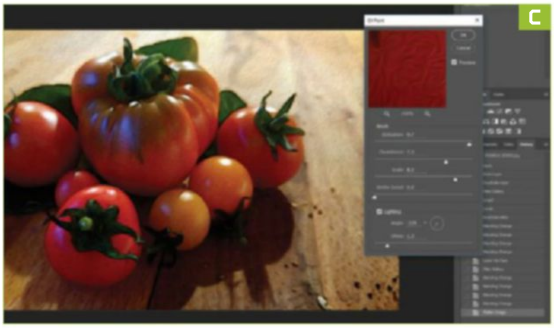
3 INVERT COLORS

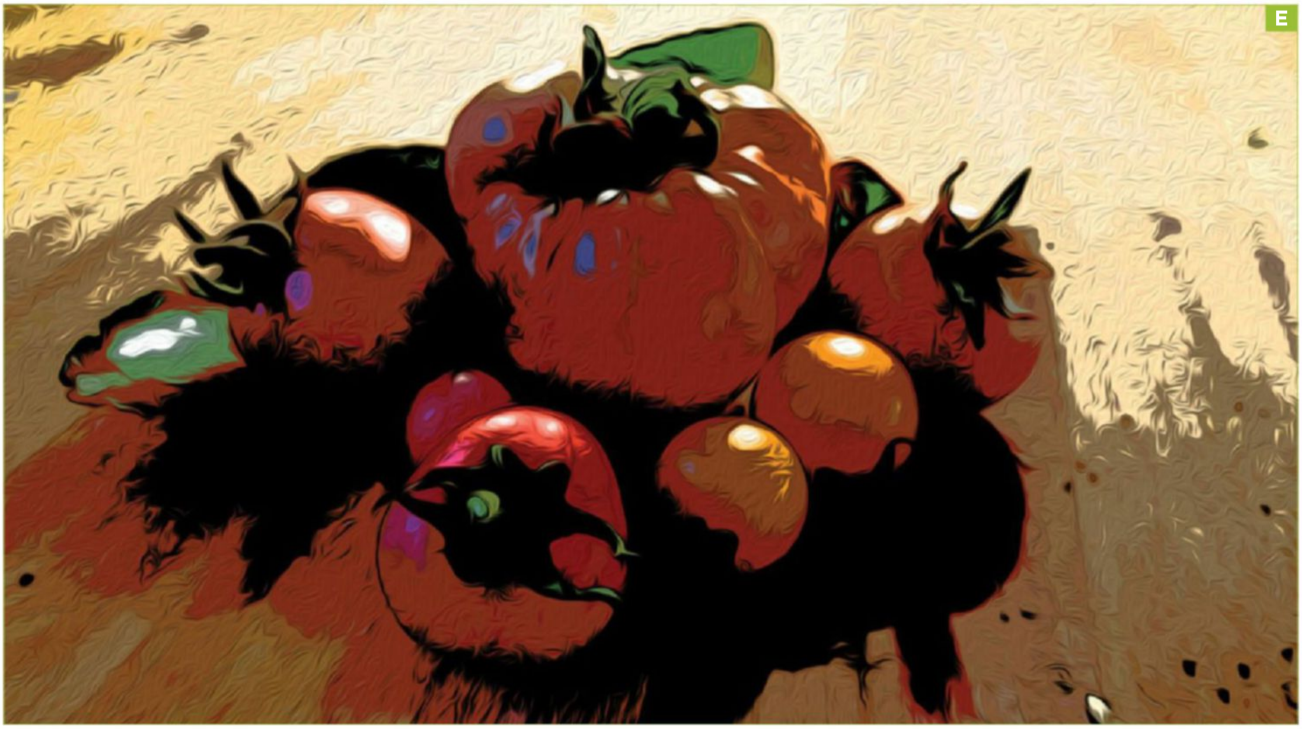
Make sure the filtered layer is selected, then go to "Image → Adjustments → Invert" to invert the colors, making the blacks white. Then bring up the "Hue and Saturation" window (Ctrl-U), and slide the saturation right back to the left, removing all color, and rendering the layer gray. Finally, set the "Blend Mode" of the top layer to "Color Burn." You should now have something looking like your original, but with a bit of texture and some dark edges in the image.



4 USE OIL PAINT

It might not look like much so far, but we're about to make huge changes. Flatten down your layers, as we're not going to need them any more, then head to "Filter → Stylize → Oil Paint." This is where you'll see the Prisma look really begin to take shape. The filter's window opens, and you're presented with some sliders and, annoyingly, a "Preview" button that's not checked. Check it. It may put a bit more load on your processor, but there's no substitute for being able to see what you're doing. Play with the sliders until you've got something that looks good. For us, it was some heavy use of the "Stylization" and "Cleanliness" controls—Prisma's brush strokes can be very deep and noticeable—with "Scale" to the right, too, but "Bristle Detail" pulled all the way to the left, to make a smooth result [Image C]. We used the "Lighting" control to bring the light over the corner of the picture that was already brighter, but didn't feel it made much of a difference. As always, experiment, and discover what looks good.



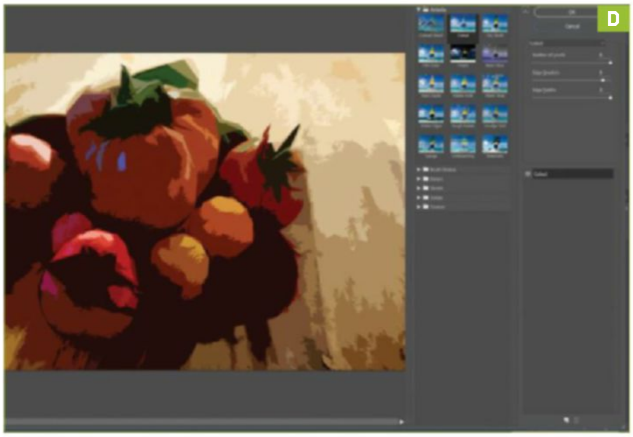


5 REDUCE COLORS

When you're happy, "OK" this step. You should now have something that looks like Prisma might have produced it. One thing it has, however, that no Prisma image would, is a lot of colors. We can reduce the number of colors in the image by going to "Image → Adjustments → Posterize." For us, a level of 10 to 15 produced a good result. Anything higher didn't look much different from the original, while pushing it lower looked very artificial.

6 TAKE IT FURTHER

You could stop now. It's already a picture that looks like an oil painting. But if there's a little voice inside you going, "Take it further!" then head out to the "Filter Gallery" again ("Filter → Filter Gallery"), hide "Glowing Edges" if it pops up again after being used earlier, and select "Cutout" from the "Artistic" set. This will almost certainly ruin your picture, but by toning down its default settings, you can produce something nice-looking [**Image D**]. An annoying thing about "Filter Gallery" is that its preview window always opens at 100 percent zoom, so use the tiny minus button (-) bottom-left to zoom the view out until the whole image fits in the window.



7 APPLY POSTER EDGE

We found that taking all three sliders almost all the way to the right produced something pleasing, but this will vary depending on your image. If using a portrait of a loved one, be careful not to obliterate their features. If you want to put some contrast back, create a new filter layer on top of the "Cutout" one (the rectangular area bottom-right of the "Filter Gallery" window works a bit like the "Layers" palette, in that you can create new layers, delete them, and change their stacking order), and apply the "Poster Edges" filter in the "Artistic" set. Keep the "Posterization" slider to the left, as we already posterized earlier.

8 FINISHING TOUCHES

Once you're happy, hit "OK." Finally, "Oil Paint" your image again to bring back the brush stroke effect if it's been lost. Save as a JPEG for sharing online [**Image E**], taking care not to write over your original file.

FILTERS

Filters are one-shot commands that will change your photo. Mobile apps, such as Instagram or Prisma, use them as an end in themselves, but in Photoshop, they're more subtle, come with more options, and are best used in combinations, or on only part of an image. Once you're familiar with the effects Photoshop's filters have, you will start to see them everywhere in advertising, product packaging, and even games—any game wanting a force field effect, for example, might use a 2D, partially transparent image generated with the "Difference Clouds" effect found under "Filter → Render." Single-shot use of filters is something to be avoided. Always try to build up an effect using several, if you can.

Build Your Own Chromebook

YOU'LL NEED THIS

CHROMIUM OS
From http://arnoldthebat.co.uk.

LAPTOP
Any spare laptop should do.

THE FIRST QUESTION in your head is probably, "Why would I want to install Chrome OS, even on my old laptop, when there are perfectly adequate full-fat Linux distros to choose from?" Good question, and the answer is that not everyone wants a full-fat distro, nor can everyone use a full-fat distro. Part of the success of Chromebooks—and they are successful, with Chromebooks outselling Apple Macs in the United States in the first quarter of 2016—is their cut-down, lightweight Gentoo-based operating system. If you want to give someone easy, no-fuss access to Google services, it should be a tempting choice. –**NEIL MOHR**

1

CHROMIUM VS. CHROME

The good news is it's easy to install Chromium OS [Image A], the open-source project name for the official Google Chrome OS, which is only available through officially licensed Chromebook PCs. While it looks superficially different, with a blue theme running through it, Chromium OS taps into the same Google accounts and services, and offers the same advantages of automatically picking up your plugins and the rest, which are stored in the Google cloud.

2

CHOOSE YOUR HARDWARE

Built on Gentoo, Chromium OS is Linux-based, so has all the advantages of the Linux kernel—but keep in mind it was only rolled out in late 2009, so if you're planning on trying it on hardware older than that, you might not have as much luck. Having said that, we tried it on a standard Lenovo X200 laptop from 2008, and everything worked without a hitch. A general rule of thumb is: Any standard Intel hardware should work without trouble. One thing we do know is that non-Intel wireless adapters do cause issues; we'll go into this in more detail in a moment.

3

PICK A BUILD

A number of websites have maintained builds of Chromium OS. It's unlikely you'll want to build it yourself from source, so there are versions ready for VirtualBox, and for running and installing off a USB drive. We're using the build maintained at http://arnoldthebat.co.uk because it remains current at the time of writing. Another popular build can be downloaded from the Hexxeh website (http://chromeos.hexxeh.net). However, this doesn't appear to have been updated since April 2013, but it does still work.

4

TAKE CHROMIUM OS FOR A SPIN

You've got an array of options for trying Chromium OS. The easiest of them is to download an image, write it to a USB drive or SD card, and then boot this from your laptop or PC. There are live disc versions, too, but with writable media, you're able to save your settings and carry the operating system around with you, so you can use it on any machine.

5

STEP HEAD STYLE

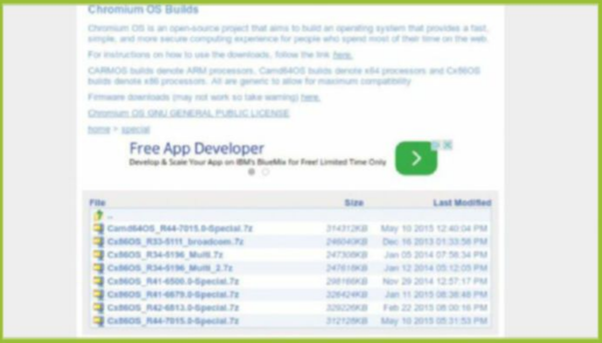
It's not advertised within the operating system, but there's a command that easily copies the OS partitions to an internal hard drive. This does wipe all existing data, but with cheap SSDs, it's not beyond the realms of possibility that you could buy a dedicated drive for this project. We did try dual-booting Chromium with Linux Mint, but it seems as though Chromium saw this as a repair state, and wouldn't play ball. Let us know if you have more luck, because it seems to be a relatively straightforward process to recreate the two ROOT-A and STATE partitions, then `dd` over these from the USB drive, and update Grub.

GOOGLE API KEYS

This part of the walkthrough isn't strictly necessary, and frankly, it's a pain in the butt to implement, because the keys are long, and if your font obfuscates "1," "L" and "I," then it's a pain to enter as well. However, if you want the Chromium Files app to work nicely with your external Google Drive account, this is the way to do it. You first need to get the keys from https://console.developers.google.com. Under "API," you need to select "Credentials," followed by "Create New Client ID for Installed Applications and Other Type," then select "Create New Key." Two entries with your API, ID, and Secret key will be listed. The second major step is adding the environmental variables to Chromium. In Vi, add the following three lines to the end of the configuration file, along with your new keys.

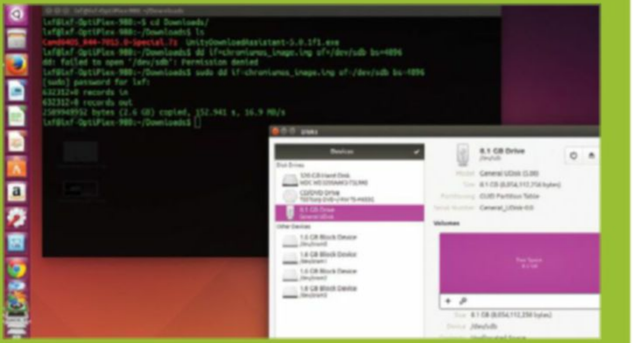
```
GOOGLE_API_KEY=
GOOGLE_DEFAULT_CLIENT_ID=
GOOGLE_DEFAULT_CLIENT_SECRET=
```

INSTALL AND UPDATE CHROMIUM OS



1. GRAB A BUILD

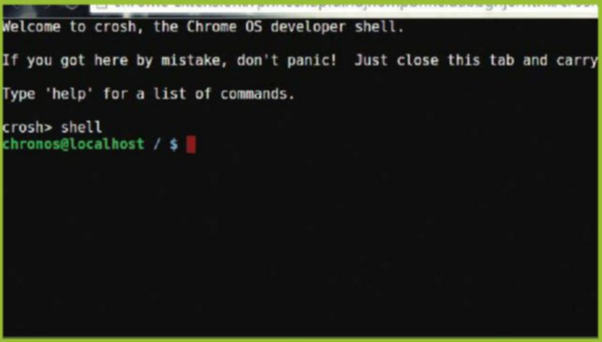
Grab the latest special build from http://bit.ly/2bh9TsJ—these builds retain all previous drivers, including Broadcom wireless, plus untested Realtek and Atheros wireless cards. Note the Cx86OS and Camd64OS builds for 32-bit and 64-bit support, so ensure you grab the correct version for your hardware to make the most of your memory.



2. BOOT MEDIA

The 7ZIP file is about 1GB in size, and is a 2.4GB uncompressed IMG file. This needs to be `dd`'d to a suitably large USB device or SD card. You are able to run and use Chromium OS from this, but installing it on an internal SSD or HDD is the best option for speed, obviously:

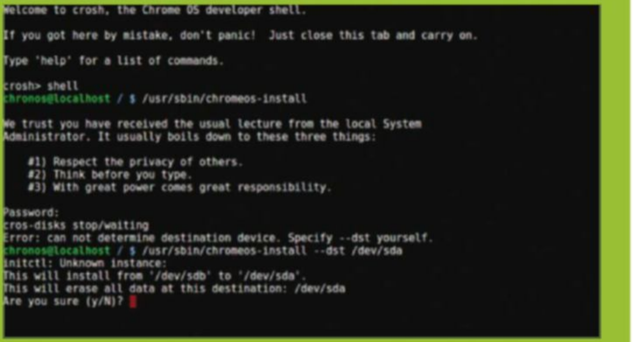
```
$ sudo dd if=<ChromeOSname.img> of=/dev/sdbX bs=4M
```



```
Welcome to crosh, the Chrome OS developer shell.

If you got here by mistake, don't panic!  Just close this tab and carry

Type 'help' for a list of commands.

crosh> shell
chronos@localhost / $ 
```

3. START CHROMIUM OS

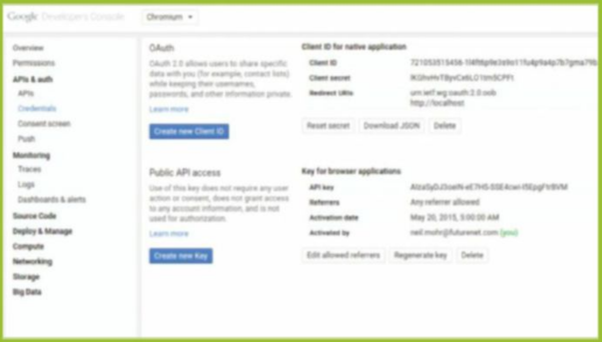
Boot your laptop with the USB stick. You'll likely need to do the magic F12/Del/Special key to adjust the BIOS/UEFI boot priorities. You don't need to log into an account, as you can use the Guest account option. Press Ctrl-Alt-T to open the developer Chrome shell Crosh. Type `shell` to open a real Linux shell.



```
Welcome to crosh, the Chrome OS developer shell.

If you got here by mistake, don't panic!  Just close this tab and carry on.

Type 'help' for a list of commands.

crosh> shell
chronos@localhost / $ /usr/sbin/chromeos-install

We trust you have received the usual lecture from the local System
Administrator. It usually boils down to these three things:

    #1) Respect the privacy of others.
    #2) Think before you type.
    #3) With great power comes great responsibility.

Password:
cros-disks stop/waiting
Error: can not determine destination device. Specify --dst yourself.
chronos@localhost / $ /usr/sbin/chromeos-install --dst /dev/sda
initctl: Unknown instance:
This will install from '/dev/sdb' to '/dev/sda'.
This will erase all data at this destination: /dev/sda
Are you sure (y/N)? 
```

4. INSTALL CHROMIUM OS

Warning! The next command wipes the entire internal hard drive—we didn't have much luck with dual-booting. If you're prompted for a password, use "password." At the shell, `$ /usr/sbin/chrome-install --dev /dev/sda` and away the install goes. Once complete, remove the USB stick and reboot.



5. GET THE API KEYS

Everything works, but parts of the OS can't access Google services without signed keys. Subscribe to the Google Code group at http://bit.ly/2d2Q0qB, then access https://console.developers.google.com, and select "Create Project." Enable Drive API/SDK, Google Maps Geolocation API, and Google Now for Chrome API.

6. ADD THE KEYS

The keys are case-sensitive, so carefully enter them when asked for the password, which is "password." To do this, open Crosh, `$ shell`, `$ sudo su`, `$ mount -o remount,rw /`, `$ cd /etc`, `$ vi chome_dev.conf`. In Vi, enter the keys as detailed in the boxout (see left). Press Esc `wq!`, log out, log back in, and Chromium Files should now have access.

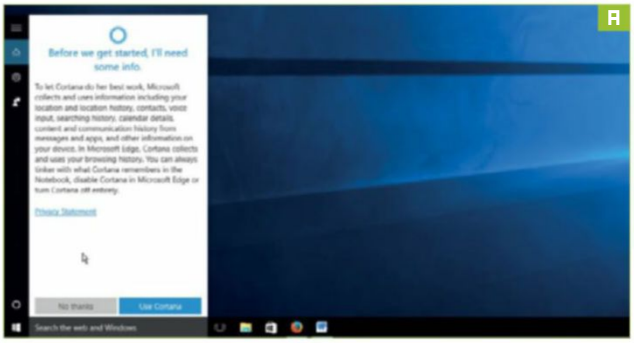
Customize Personal Assistant Cortana

YOU'LL NEED THIS

WINDOWS 10
Cortana is built in to Microsoft's latest OS.

FIRST INTRODUCED ON HANDSETS running Windows Phone, Microsoft's virtual personal assistant, Cortana, arrived on the desktop with the launch of Windows 10. Named after the artificial intelligence from science-fiction game series *Halo*, Cortana is much more than just a search tool—it also manages your calendar, tracks packages, and will even tells jokes.

Cortana packs in more features than Apple's assistant Siri, or Google Now, and you can make it even more personal by customizing your settings to reflect your interests, activities, and preferences. It works together with Microsoft's wealth of programs and tools, to help you get even more from your PC. So, let's get started! –**CAT ELLIS**


A
Before we get started, I'll need some info.
Privacy Statement
No thanks
Use Cortana
Search the web and Windows

1 MEET CORTANA

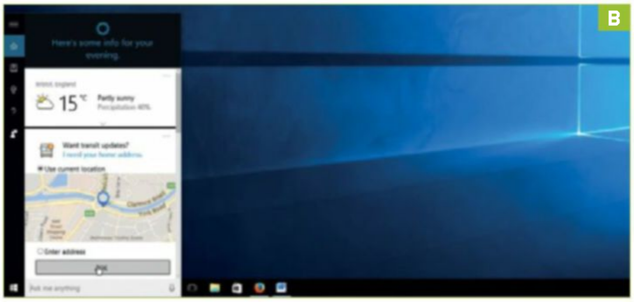
Cortana is accessed by clicking the "Search" box beside Windows 10's "Start" button. If an introduction to Cortana [**Image A**] doesn't appear, click the circle icon on the left-hand side of the menu. Click "Next," then click "Use Cortana" to continue. You can now control Cortana by typing into the search box, or by clicking the microphone icon and speaking—more on that later.

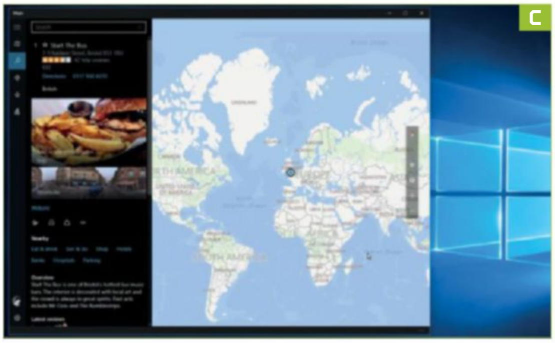
2 WHERE ARE YOU?

Cortana automatically picks up your location and displays it on a map, along with a weather report [**Image B**]. If you're not currently at home, you can enter your address, and Cortana provides information such as traffic reports, so you know what to expect on the roads. It also synchronizes with your Google or Outlook calendar, and provides reminders about upcoming events.

3 FILL IN THE BLANKS

Like any personal assistant worth their salt, Cortana keeps a "notebook" full of information about the boss—that means you! To fill in the blanks in this notebook, and improve your experience with Cortana, click the third icon down in the menu on the left, and choose "About me." Here, you can tell Cortana your name (and how to pronounce it, if necessary).



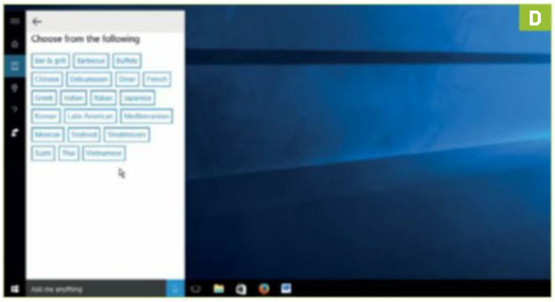


4 FAVORITE PLACES

It's also worth adding some of your favorite places to the notebook. These could include your office, friends' addresses, favorite stores, and more. Once you've entered a place, you can click it for more information, including a map, contact details, reviews, prices (for stores, restaurants, and hotels), directions from your current location, and other places to visit nearby [**Image C**].

5 NOTEBOOKS AND CARDS

Giving Cortana details about your preferences improves the quality of search results and recommendations, so move through each of the topics listed in the notebook [**Image D**], and enter as much information as you like. Each of these subjects relates to what's known as a "card"—a page of information relevant



PERSONALIZE YOUR SETTINGS

1. CUSTOMIZATION MENU
Click here to see Cortana's options, including "Notebook," "Reminders," "Help," and "Feedback."

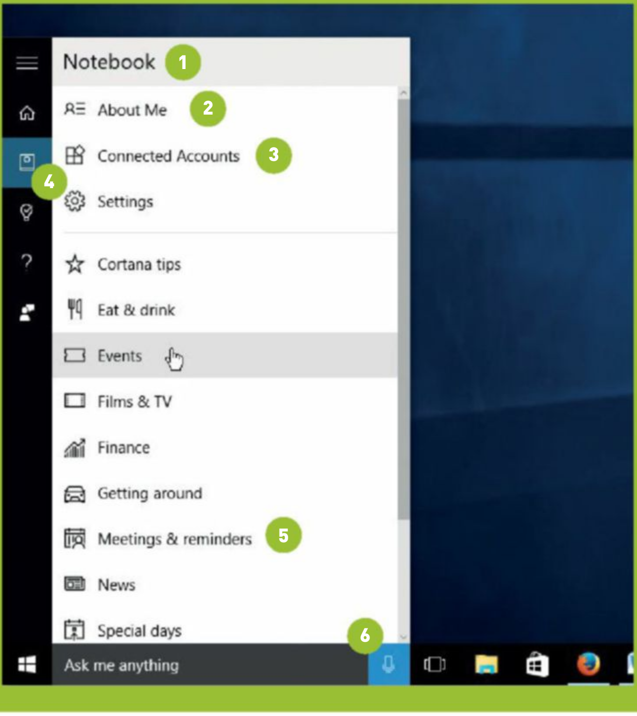
2. ABOUT ME
Here you can tell Cortana your name and some of your favorite places. These could include your home, work, and favorite restaurants, for example.

3. CONNECTED ACCOUNTS
Cortana can connect to LinkedIn, Xbox Live, Office 365, and Dynamics CRM (for businesses) to give you tailored information and alerts.

4. CARDS
You can provide Cortana with information about your interests and preferences, to make its suggestions more relevant.

5. REMINDERS
Ask Cortana to prompt you at a certain time, or a particular place. You can also add contacts from your address book, if you're meeting people.

6. VOICE CONTROLS
You can type questions into the search bar, or use voice commands (much like Apple's Siri).



to your interests. Some of the settings are quite esoteric, but you can deactivate them.

6 MAKE CONNECTIONS

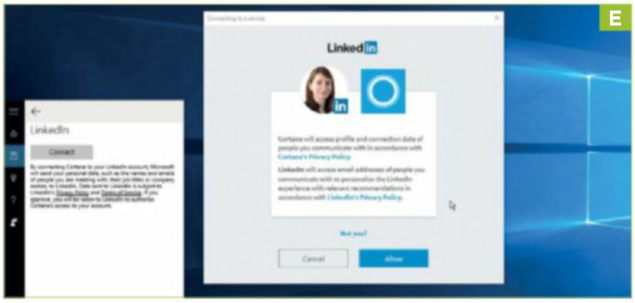
You can make Cortana even more useful by connecting other accounts. For example, connecting your LinkedIn account [Image E] can give you information about people you're scheduled to meet, and connecting your Xbox Live account lets you know when your friends are online, and provides relevant information about the games you enjoy playing.

7 VOICE COMMANDS

To control Cortana with your voice, click the microphone icon beside the search box. Cortana detects any microphones connected or built in to your PC, and asks you to read a sentence aloud, so it can adjust the input volume. You can then use commands such as, "Play all my songs" or "What is it like outside?" Plug in headphones or speakers to hear the responses.

8 HEY CORTANA

Cortana's settings (beneath "Linked accounts" in the notebook) enable you to customize voice controls further [Image F]. You can activate the assistant by saying "Hey Cortana" (but this drains the battery of mobile devices, because the mic is always on), and train it to recognize your voice, to avoid it being activated by someone else nearby.

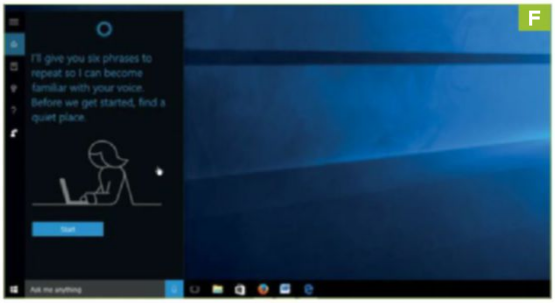


9 THE GOOGLE OPTION

Bear in mind that commands issued to Cortana are always performed using Microsoft tools—so web searches and weather reports use Bing, emails use Outlook, and music is played using Groove Music. If you prefer to use Google Search, Gmail, Google Calendar, and so on, you're better served by Google Now. However, Now is only available for mobile devices.

10 TELL US A JOKE

Now that you've customized Cortana, try asking a few questions, such as: "Is there a coffee shop near me?" "What's in my diary for Friday?" What restaurants are near me?" "How long will it take to get to work?" "What is the weather like?" You can also ask to hear something funny, although the groan-worthy jokes might make you wish you hadn't! ⏻



I'll give you six phrases to repeat so I can become familiar with your voice. Before we get started, find a quiet place.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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msi
DYNAUDIO
steelseries

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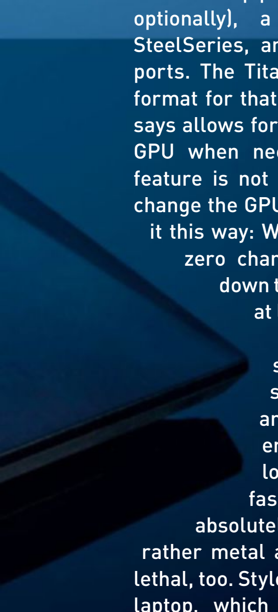
DYNAUDIO
steelseries

Genuine desktop performance in a portable package? That'll be the MSI Titan Pro.

MSI GT73VR Titan Pro

Nvidia's awesome GTX 1080 graphics presented in a portable package



THERE'S MOBILE GRAPHICS. And then there's proper gaming graphics. For a taste of the latter in a portable package, look no further than MSI's new GT73VR Titan Pro. It's a beefy 17-inch portable with Nvidia's stupid-quick GeForce GTX 1080 graphics.

The point is that it really is a GTX 1080 chip. Over the years, both Nvidia and its main rival, AMD, haven't always played it straight with their laptop graphics chips. All too often, the mobile version of a given GPU wasn't quite what it seemed. But not this time. This is no GTX 1060 with a lick of paint. It's the real 2,560-CUDA-core deal.

That GeForce GTX 1080 GPU is just the beginning of what is an epic feature set. There's a quad-core Intel Core-i7 6820HK CPU, which clocks in at 2.7GHz nominal and 3.6GHz Turbo. Next up, MSI has stuffed in a pair of 256GB Samsung PCIe SSDs running in RAID 0, plus a 1TB 7,200rpm magnetic drive, and a preposterous 32GB of RAM.

Then there's support for 120Hz refresh on the 1080p panel (a 4K panel is available optionally), a backlit keyboard from SteelSeries, and a veritable plethora of ports. The Titan Pro also uses the MXM format for that GTX 1080 GPU, which MSI says allows for a change or repair to your GPU when needed. MSI also says this feature is not intended for end-users to change the GPU themselves. But, let's put it this way: With most laptops, you have zero chance of upgrading the GPU down the road; with this thing, you at least have half a chance.

The Titan Pro has some serious cooling, too, speakers from Dynaudio, and countless other detail enhancements, including low-lag Ethernet for super-fast ping. On paper, then, it's absolutely killer. In the flesh, or rather metal and plastic, it looks pretty lethal, too. Style-wise, it's a typical gaming laptop, which makes it either suitably aggressive or a little adolescent, depending on your preference. At just over eight and a half pounds, it's transportable, rather than slip-into-your-manbag portable.

The SteelSeries keyboard certainly adds a little color and a stable input platform, though it's worth noting that the soft tactility of the keystroke is nothing like a mechanical desktop keyboard. The 17.3-inch 1080p display, meanwhile, is something of a mixed bag. In broad terms, the rendering is gorgeously smooth, thanks to that 120Hz ability. The colors and contrast are also reasonable. But the viewing angles are merely mediocre. MSI doesn't reveal the panel type, but our seasoned eyes suggest it's a TN panel.

FLYING HIGH

But what of the most important question: performance? Put simply, this thing flies. The quad-core Intel CPU is a known quantity, of course, but those Samsung SSDs in RAID 0 absolutely scream, pumping out GB/s of raw bandwidth, even if the 4K random access is less spectacular. But what you really want to know is whether that GTX 1080 GPU delivers. In a word, yup. The specs, including core and memory clocks, are almost identical to a full desktop GTX 1080. You probably wouldn't be able to tell the difference in gameplay.

Factor in the modest 1080p display resolution, and the Titan Pro makes absolute mincemeat of our gaming benchmarks. It tears through *Rise of Tomb Raider* at high detail at 98fps, and knocks out over 60fps in *Tom Clancy's The Division*. Even *Far Cry Primal*, set to full reheat, hits a heady frame rate of 67. Heck, you even get around three hours of real-world web browsing battery life, which isn't bad for this kind of beast.

Set against all that are three provisos. First is the aforementioned girth—this is a massive machine. Second is the build quality. Like pretty much all laptops in this class, the plastic chassis is underwhelming. Finally, there's the price. Suffice to say, it ain't cheap. But if it's maximum gaming performance in a somewhat portable package you want, it might just be worth it. –**JEREMY LAIRD**

VERDICT

8

MSI GT73VR Titan Pro

⊞ **BEAUTY** Stunning graphics performance; massive feature set; some possibility of future graphics upgrades.

⊟ **BEAST** Pricey; mediocre build quality; not particularly portable; kicks out plenty of heat and noise.

$3,099, www.msi.com

SPECIFICATIONS

Processor	Intel Core-i7 6820HK
Graphics	Nvidia GeForce GTX 1080 8GB
RAM	32GB
Resolution	1920x1080
Display Type	17.3-inch TN
Storage	2x 256GB PCIe SSD, 1TB 7,200rpm HDD
Connectivity	5x USB 3, ac Wi-Fi, Gb LAN, Thunderbolt, HDMI, DisplayPort
Dimensions	16.9 x 11.3 x 0.9-1.1 inches
Weight	8.6lb
Warranty	One year

BENCHMARKS

	ZERO-POINT	
Cinebench R15	682	669 (-2%)
x264 HD 5.0 (fps)	15.17	16.5 (9%)
CrystalDiskMark 4K Read (MB/s)	44	47 (6%)
CrystalDiskMark 4K Write (MB/s)	162	153 (-6%)
Far Cry Primal (fps)	37	63 (70%)
The Division (fps)	33	67 (103%)
Rise of the Tomb Raider (fps)	42	98 (133%)
3DMark Fire Strike	6,583	14,716 (123%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, a 3GB GTX 970M, and 16GB of DDR4-2133. *Far Cry Primal* and *The Division* tested at Ultra settings at 1080p. *Rise of the Tomb Raider* tested at Very High settings with SMAA at 1080p.

ASUS X99-E-10G WS
ASUS
M.2 x4

Asus: Making motherboards great again.

Asus X99-E-10G WS

The epitome of workstation heaven?

WHAT DO YOU LOOK FOR in a motherboard? Clean style? Endurance? Good power draw? Never-ending connectivity? There's a lot to think about when choosing the perfect motherboard. Much like a processor, you need one that's appropriate for your build; suitable for what you want to do. In a lot of ways, it's a contradictory component; by its very nature, it's oxymoronic—without it, your system cannot run, but in terms of computational performance, it adds very little. Just take a look at our benchmarks, and you'll see that the differences between these boards are slim at best. Games, in particular, do not benefit in any perceivable way, performing exactly the same on a $200 board as they would on one that costs three times as much. In fact, what we look for during testing are any significant discrepancies between them. At which point, we delve into the inner workings to figure out what exactly is going on.

With that in mind, let's take a look at this beautiful piece of craftsmanship from Asus, the X99-E-10G WS. Part of Asus's Workstation lineup, these HEDT monsters are designed solely for industry professionals, those people who need the absolute maximum when it comes to both connectivity and processing power; to power systems capable of dishing out hard 3D encodes and renders at a ridiculous rate of knots. It's for those people that this particular board has been designed, and it's not until you reel off the spec sheet that you truly appreciate just how much has gone into making that concept a reality. The E-10G features seven PCIe x16 slots, dual 10 Gigabit Ethernet, support for 128GB of DDR4 up to 3,333MT/s, one U.2 header, one M.2 PCIe x4 slot, 10 SATA3 6Gb/s ports, dual eight-pin EPS processor power, and an additional six-pin PCIe power for the board, ultimately supporting four-way SLI and CrossFire, and more.

BYE-BYE RAMPAGE V

In short, it takes the likes of ROG's prestigious Rampage V and throws it under the bus, with more connectivity, better overclocking potential, and a style that, let's face it, is beautiful. "But, *Maximum PC*, four-way SLI and CrossFire are pointless. Why are you ignoring this?" Yes they are, reader. We agree. In fact, three-way is questionable, and even Nvidia's official line with the latest Pascal cards is that it's only really supporting two-way SLI going forward. But that's only for gaming. In programs such as After Effects, Premiere Pro, and their more sophisticated industry-standard brethren, the more cards you have, the better. Nvidia GPUs, in particular, leverage their CUDA cores to enable a more aggressive ray-traced 3D renderer in Adobe's Creative Cloud.

So, let's have a quick chat about performance. All in all, the X99-E-10G is a well-rounded board. Memory bandwidth is the highest we've ever seen at 54.88GB/s—still less than 3GB/s faster than the bottom end of our tested boards so far. Latency is some of the lowest we've seen (that's good), and sequential reads and writes are equally quite high. And CPU performance is, as usual for Asus, consistently high, thanks to the enhanced ratio settings, increasing overall performance by nearly 90 points in Cinebench and 100 points in Fire Strike, compared to competing brands.

All boring and bland, then? Well, not quite. The E-10G WS really shone when it came to overclocking. Most notably in how low a voltage we could apply to get that stable overclock. In our tests, we managed an astonishing 1.265V at 4.3GHz; in contrast, our EVGA X99 Micro 2 bottomed out at 1.3V. It doesn't sound like much, but when you consider that it reduces overall CPU temperatures by almost 20 C, it speaks for itself.

So, it's well rounded, full of connectivity, and overclocks better than anything we've seen. Similar to last year's TUF series, the Workstation lineup is the true king of PC performance. **–ZAK STOREY**

VERDICT

9

Asus X99-E-10G WS

+ WORLD CHAMPION Insane connectivity; incredible stability; beautiful style; low latencies; high memory bandwidth.

− WORLD CHUMP Power draw; price; limited rear I/O; price—dear God, the price.

$742, www.asus.com

SPECIFICATIONS

Chipset/Socket	X99/LGA 2011-3
Form Factor	SSI CEB
Memory Support	128GB DDR4 @ 3,333MT/s
M.2/U.2 Support	1x M.2 PCIe x4, 1x U.2
SATA Support	10x SATA 6Gb/s
Max PCIe Support	7x PCIe 3.0 x16 (x16/x8/x8/x8/x8/x8/x8)
Rear I/O	5.1-channel audio, SPDIF-out, 4x USB 3.0, 1x USB 3.1 Type A, 1x USB 3.1 Type C, 2x 10Gb/s Intel NIC

BENCHMARKS

	Asus X99-E-10G WS	Asus X99 Strix Gaming	EVGA X99 Micro2
Tech ARP x264 v5.0.1 (fps)	39.03	**39.07**	37.09
Cinebench R15 (index)	1,851	**1,859**	1,765
SiSoftSan Memory Bandwidth (GB/s)	**54.88**	54.21	51.74
AIDA64 Memory Latency (ns)	**69.4**	72.2	74.4
CrystalDisk Read/Write (MB/s)	**550**/520	**550/530**	545/523
Power Draw Idle/Peak (Watts)	98/415	67/365	**63/349**
Far Cry Primal @ 4K (fps)	**42**	**42**	**42**
Maximum Overclock Achieved (GHz)	4.3	**4.4**	4.3
Minimum VCore @ 4.3GHz (Volts)	**1.265**	1.31	1.30

Best scores are in bold. All benchmarks performed with an Intel Core i7-6950X, 32GB of DDR4 2400 (4x 8GB), GeForce GTX 1080, and a Samsung 850 Evo 500GB.

EVGA GeForce GTX 1060 3GB Gaming

Nvidia claims the throne once again

THE BACK AND FORTH struggle between the two titanic graphics manufacturers is what the GPU race is all about. Don't be mistaken: this is an arms race. A race to find the best value card. For Nvidia, it's all about retaining its horrendously progressive market share, while AMD is chinking away at Nvidia's armor, outmaneuvering it to sink its own teeth back into the juicy flesh of mainstream superiority. From month to month, prices change and margins shift, as each side competes for your hard-earned cash. What does that mean? In short, it means better value for us, the consumer. It's pretty hard to argue that this isn't a good thing. Competition is always going to be good for the majority.

With the launch of Polaris 10 and 11, AMD dominated the low end of the market, thanks to its RX 480. In fact, it was our favorite card last issue. However, it seems that, at last, it has a competitor—not in the form of the $300 Founder's Edition GTX 1060, but in its slightly lower-specced 3GB little brother. Indeed, that's why we're reviewing this card right now—because the spec variance extends far beyond a simple drop in overall VRAM.

So, for your money you get 1,152 CUDA cores (128 fewer than the 6GB version), the same number of transistors at 4.4 billion, the same GPU die size, the same TDP, the same memory bus at 192-bit, and a reduction in overall VRAM from 6 to 3GB of GDDR5, still allowing for 192GB/s of memory bandwidth. But it's that drop in CUDA cores that really caught our eye. In fact, you'd be forgiven for viewing this as a GTX 1050 out of the gate.

PERFORMANCE DEFICIT?

There's a good reason why those 128 extra cores have been disabled, and we believe this is down to generating a greater performance deficit between the two variants. In our testing last issue, we noticed that the difference between the 8GB and 4GB variants of the RX 480 was minimal at best, but with a slight drop in CUDA cores, it's possible to see a more substantial shift in performance between the two cards. That's not to say that the GTX 1060 3GB is a bad card—not at all—it's just been slightly handicapped to ensure it doesn't compete quite so closely with the full-fledged variant of the GTX 1060.

So, let's get to the point: performance. It's good. Incredibly good for the price. EVGA's advanced single-fan cooling solution on the GTX 1060 is nothing short of awe-inspiring. It's quiet, cool, and has a smaller footprint than Kanye West's talent. At 1080p, this card dominates those frame rates. Our testing suite showed average frame rates of 61fps in *Far Cry Primal*, as opposed to 66 from the 6GB version, 35fps in *RotTR*, compared to 38, and 36 in *Attila*, against the 6GB's 38fps. At 1440p, the playing field evens out a little further, with the two cards being within 1-2 frames per second of one another. *Far Cry Primal*, at ultra with HD texture packs, showed VRAM usage at 83 percent at most. Not too shabby for a 3GB card.

What can we say about the GTX 1060? It's still extremely close to the likes of last-gen's GTX 980, and for a price that, to be honest, is nigh on ridiculous. And since the price of the RX 480 4GB has gone up again to $230, this makes the 3GB GTX 1060 insanely good value for money, trumping last issue's GPU group test winner. Is it going to be ideal for 1440p and above? Well, yes and no—that depends entirely on what games you run frequently, but it'll certainly have a crack at running most titles comfortably in the mid-40s range. All in all, it's a gorgeous little number, with some neat power savings and a tiny form factor, and it brings some competition back to the market at a time when we, the consumer, desperately need it. **–ZAK STOREY**

VERDICT
9

EVGA GeForce GTX 1060 3GB

+ EFFORTLESS Exceptional 1080p performance; solid 1440p performance; crazy price point; quiet; cool; small.

– STRUGGLE No SLI support.

$210, www.evga.com

BENCHMARKS

	EVGA GeForce GTX 1060 3GB Gaming	AMD Radeon RX 480 8GB	Zotac GeForce GTX 1060 AMP! Edition
Fire Strike @ 1080p (Index)	10,251	10,542	**11,164**
Fire Strike Extreme @ 1440p (Index)	5,377	5,205	**5,835**
Fire Strike Ultra @ 4K (Index)	2,779	2,725	**3,002**
Total War: Attila (fps)	24/36	21/30	**26/38**
Far Cry Primal (fps)	49/61	48/61	**53/67**
The Division (fps)	31/55	34/**58**	**43/58**
Rise of the Tomb Raider (fps)	9/35	11/34	**28/45**
Price Per FPS	**$6.72**	$7.66	$8.23

Best scores are in bold. Game results are minimum and average fps at 1440p. Our testbed consists of a Core i7-6700K, with 16GB of Kingston Savage DDR4 @ 2,400MT/s on an MSI Z170A Gaming M7 motherboard.

SPECIFICATIONS

GPU	Pascal
Lithography	16nm FinFET
Transistor Count	4.4 billion
CUDA Cores	1,152
Texture Units	72
ROPs	48
Core/Boost Clock	1,506/1,708MHz
Memory Capacity and Type	3GB GDDR5
Memory Speed	8GHz
Memory Bus	192-bit
TDP	120W
Display Connectors	DisplayPort 1.4, HDMI 2.0b, Dual Link-DVI

EVGA
GEFORCE GTX 1060
DESIGNED BY EVGA

It may be tiny, but this card packs a punch at 1080p.

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XFX Radeon RX 460

An esports card, but is it worth it?

AMD'S HAD AN INCREDIBLE RUN since the launch of Polaris. Indeed, the RX 480 has scooped up a number of awards. The GTX 1080 may be the king of the frame rates, but it's the dollars per fps that cinch the deal for us. So, how far can you push the value bracket before things go asunder?

AMD's Radeon RX 460 is a $130 low-end budget card. Aimed at esports gaming, particularly *League of Legends* and *DOTA II,* it's not a great pixel-destroyer, nor is it capable of channeling AAA titles at acceptable frame rates. That said, that's how we do most of our testing, so to ignore it would be ludicrous, regardless of how much AMD moans at us about it.

So, for a meager $130, you can grab a sizable chunk of Polaris 11. With currently only the RX 460 in this tiny 14nm graphics family, this variant comes with three billion transistors, 896 shader units, and 2GB of GDDR5 on a 128-bit bus, allowing for a total memory bandwidth of 112GB/s. That's quite a drop from Polaris 10. In fact, it's over 2 billion transistors and 1,152 shader units fewer than its closest neighbor, the RX 470, which is currently available for $190. That's a $60 difference for more than double the performance of the RX 460. And, boy, does it show. At 1080p, the RX 460 hardly competes in our benchmark suite, scoring a paltry average frame rate of 14 in *Attila,* 12 in *Rise of the Tomb Raider,* and 30 in *Far Cry Primal,* a game well known for its solid optimization in our benchmarks.

Yes, cynics will be saying, "Well, it's not built for that," and we have to agree: no, it's not. Its design ethos is entirely centered around esports. If you're an esports gamer, you're going to want this, right? Thing is, you don't just play one game for eternity. Perhaps you're not interested in grinding out ladder today, but instead want to jump into an RPG, or the latest *Assassin's Creed,* or *Project Cars*? Well, if you chose this card, you couldn't, not without dropping the graphical settings quite considerably.

The pros, who play *CS:GO, LoL, DOTA II,* or *Overwatch* every day, already have top-end cards, because they want the highest frame rates, and the quickest refreshes they can get. And more casual esport gamers aren't going to be dedicated enough to not play other games on the side.

We keep seeing this trend—products designed with such a niche market in mind that they fail to excel at what they were designed to do. Intel's latest NUC, for example, had the whole gaming nomenclature down to a T, yet struggled with gaming. These are products that are still very impressive, but the marketing divisions seem content to stick labels on them that simply don't fit.

For what it's worth, for its overall die size, the GPU at the heart of the RX 460 is an incredibly strong performer. But for the price, it's way off. And considering you have the likes of the RX 470 and 4GB 480 costing only $60 to $90 more, it simply doesn't make sense as to why this card is priced so high. It's a budget option, which has a price to performance efficiency comparable to a Fury X or GTX 1070—but without the performance. **–ZAK STOREY**

VERDICT
6

XFX Radeon RX 460

+ **RADICAL** Low power; small form factor; good for MOBAs.

− **ROTTEN** Price; incompatible with *Ashes;* poor price to performance; limited gaming.

$130, www.amd.com

BENCHMARKS

	XFX Radeon RX 460	MSI Radeon RX 470
3DMark Fire Strike @ 1080p	5,206	**10,582**
3DMark Fire Strike Extreme @ 1440p	2,507	**5,028**
3DMark Fire Strike Ultra @ 4K	1,039	**2,657**
Total War: Attila	1/14	**21/28**
Far Cry Primal	23/30	**44/54**
The Division	17/29	**36/55**
Rise of the Tomb Raider	2/12	**9/31**
Price Per FPS	$9.29	**$6.45**

Best scores are in bold. Game results are minimum and average fps at 1080p. Our test bed consists of a Core i7-6700K, with 16GB of Kingston Savage DDR4 @ 2,400MT/s on an MSI Z170A Gaming M7 motherboard.

SPECIFICATIONS

GPU	Polaris 10
Lithography	14nm FinFET
Transistor Count	3 billion
Shader Units	896
Texture Units	56
ROPs	16
Core/Boost Clock	1,090/1,200MHz
Memory Capacity and Type	2GB GDDR5
Memory Speed	7GHz
Memory Bus	128-bit
TDP	75W
Display Connectors	HDMI 2.0, DisplayPort 1.4

Asus ROG Swift PG248Q

Hertz so good: 180Hz gaming has arrived

SO GOOD IT HERTZ. That's the thinking behind the new 180Hz-capable Asus ROG Swift PG248Q. To put it another way, more hertz in the form of a higher refresh rate is necessarily a good thing.

Up to a point, we agree. The step up from a standard 60Hz LCD monitor to something capable of 100Hz and beyond is pretty sweet. Nearly everything is smoother and slicker. Obviously, games benefit more than just about any other application from a higher refresh. But even bumping application windows around the desktop is more pleasant. Once you've tried high refresh, you won't want to go back.

But it doesn't automatically follow that chucking ever higher refresh rates at the problem of gaming smoothness makes sense. Eventually, you get to a point where human perception can no longer distinguish the increase. In our experience, the returns fall off beyond 120Hz. Put it this way, it's easy to pick a 120Hz monitor from a 60Hz screen with the naked eye, which is surely the point— being able to see the difference subjectively. But could you reliably identify which was which if you had two otherwise identical screens running side by side at 120Hz and 180Hz? Even if you can, do you have a graphics card that can generate frames fast enough to benefit from the full 180Hz?

Those are the questions the PG248Q needs to answer, because at $449, it costs a pretty penny for what, in many regards, is a modestly specced monitor. It's just 24 inches across, only delivers 1,920 by 1,080 pixels, and is powered by a TN panel. It's also priced perilously close to a couple of Asus's own ROG Swift monitors with larger 27-inch panels, and 2,560 by 1,440 pixel grids. One of them, the ROG Swift MG279Q, even offers an IPS panel.

This 24-inch model's value proposition only looks weaker when you actually fire it up. TN technology has come a long way of late, in terms of colors and contrast, but this thing is old-school TN in all the wrong ways. It's fundamentally lacking in visual pop and contrast. The viewing angles are modest, too, in typical TN style. Meanwhile, our test images reveal noticeable compression in white tones, along with a little banding in gradients.

That's disappointing, given that the latest 4K TN panels have genuinely good colors and contrast. TN panels don't have to be this bad. Still, offsetting all that is the undeniable performance in terms of speed and response. The PG248Q is rated at 1ms, and it feels good for it. Another obvious plus point, and one that goes some way toward justifying the pricing, is support for G-Sync, Nvidia's proprietary adaptive sync implementation. It's more costly than the FreeSync alternative from AMD, but for now, it's simply better. The PG248Q also supports Nvidia 3D Vision and 3D LightBoost tech, which is a major boon if you're into 3D stereoscopic gaming.

The top-quality stand, with the full range of height, rotate, and swivel adjustments, and the nicely put-together chassis help justify the price, too. The OSD menu is also full of features, even if the image presets are mostly useless, and the fastest overdrive setting introduces chronic inverse ghosting.

There's lots to like here for gamers, then. It's a seriously speedy screen, with a long list of desirable features. But you'd have to be awfully confident in being able to perceive the improvement in refresh rate over a 120Hz or 144Hz alternative, with superior image quality in other areas, to give this monitor even passing consideration. It's not that there's definitely no benefit to all those hertz. More that the benefit is marginal, and comes at a cost in so many other areas. For us, the fact that you have to jump into the OSD menu and enable the 180Hz refresh as an "overclocked" setting drives home that final nail. It's pure gimmickry. **–JEREMY LAIRD**

VERDICT
7

Asus ROG Swift PG248Q

⊞ **HERTZ SO GOOD** Super-quick response and refresh; loads of features; quality chassis.

⊟ **WORLD OF PAIN** Painfully pricey; low resolution; can you really tell the difference?

$449, www.asus.com

SPECIFICATIONS

Panel Size	24-inch
Native Resolution	1920x1080
Panel Type	TN
Max Refresh	180Hz
Pixel Response	1ms
Contrast	1,000:1
Inputs	HDMI, DisplayPort
VESA Mount	100x100
Warranty	Three years

How much are those extra hertz worth?

Crucial MX300 1TB

Big SSD. Small price. Give it up for 3D NAND memory

GOOD THINGS COME to those who wait, they say. If that's true, Crucial's new MX300 SSD must be smoking hot. It's Crucial's first SSD to offer 3D NAND memory technology, but it's fully two years later to market than Samsung's first SSD with 3D NAND.

When it comes to memory density and capacity, however, it looks like the MX300 has been worth the wait. Samsung's 3D NAND chips topped out at 128Gb per die at launch, and even its second-generation triple-level cell 3D NAND dies only max out at 256Gb. We say "only" because Crucial, along with production partner Intel, has come up with some beefy 384Gb TLC NAND chips right from the get go.

The large capacity of the NAND chips explains why the MX300 line comes in oddball sizes of 275GB, 525GB, the 1,050GB drive here, and 2TB. It's a function of the NAND chip capacity. As a for instance, the 275GB model has six memory dies, making for a total raw capacity of 288GB. Slice a bit off for redundancy, and you get 275GB.

Impressive, but how does it perform? Truth is, this first viewing of Crucial's 3D NAND tech isn't a performance play. For starters, the controller chipset is Marvell's 88SS1074, which is a couple of years old and a four-channel model, rather than a pricier and quicker eight-channel effort. That said, Crucial's 3D NAND does have a number of enhancements, including a fast 4K read mode that purportedly improves random access performance.

SATA SLOWDOWN

You wouldn't necessarily know that from the MX300's official IOPS performance, which clocks in at 92,000 read IOPS and 83,000 write IOPS, both of which are lower than Crucial's own MX200 drive. Similarly, the claimed 530MB/s sequential reads and 510MB/s sequential writes are nothing special. But this is an old-school SATA drive, not one of the brave new PCI Express models with GB/s of bandwidth and hundreds of thousands of IOPS, thanks to the newfangled NVMe control protocol.

What the MX300 needs to offer is lots of capacity and reliable performance at a great price. In most of our benchmarks, it does. Peak sequential throughput is near 500MB/s, which is all you can ask from a SATA drive. Likewise, there are no horrors in the 4K random access test, though the 28MB/s in the AS SSD 4K read benchmark is average, and doesn't square well with Crucial's claims of optimized 4K read performance from its 3D NAND chips. The Marvell controller may be the limitation.

Whatever, our real-world 5GB compression and 30GB file copy tests look decent, too. In fact, the 2 minutes and 58 seconds it takes to complete the compression test is one of the best scores we've seen. Our only reservation when it comes to performance involves patchy observed performance during the pre-test setup, which involves filling the drive to capacity before deleting the data.

All of which means that the MX300's appeal largely hinges on price. It doesn't need to be the cheapest 1TB SSD, but it does want to be very competitively priced. At about $40 cheaper than a 1TB Samsung 850 Evo and $25 less than a 1TB SanDisk X400, it is. It's not the fastest drive money can buy. It's also not the game changer you might hope for in terms of GB/$, given the density of its 3D NAND chips. But it's still a pretty compelling option. **–JEREMY LAIRD**

VERDICT 8

Crucial MX300 1TB

+ MARTY McFLY Impressive density from 3D NAND tech; decent performance; competitive price.

– GEORGE McFLY PCI Express SSDs are far faster; not quite the revolution in GB/$ we were hoping for.

$259, www.crucial.com

BENCHMARKS

	Crucial MX300 1,050GB	Crucial BX200 960GB	OCZ Trion 100 960GB	Samsung 850 Pro 2TB
AS SSD Sequential Read/Write (MB/s)	479/480	501/453	**513**/436	**513/499**
AS SSD 4K Radom Read/Write (MB/s)	28/113	28/109	31/92	**41/126**
ATTO Sequential Read/Write (MB/s)	418/495	559/492	**564/517**	404/427
5GB Zip (Seconds)	**178**	195	194	194
30GB Copy (Seconds)	**158**	382	263	160

Best scores are in bold. Our test bench consists of an Intel Core i7-6700K, MSI 170A Gaming M7, 16GB Crucial Ballistix Elite DDR4-2666, and a GeForce GTX 1080.

SPECIFICATIONS

Capacity	1,050GB
Interface	SATA III
Control Protocol	AHCI
Controller	Marvell 88SS1074
NAND Type	3D TLC
Sequential Read	530MB/s
Sequential Write	510MB/s
Read IOPs	92,000
Write IOPs	83,000
Warranty	Three years

Anidees AI Crystal

A tempered glass crime scene

GOOD LORD, the foam packaging surrounding this case is impressive. No, seriously—hear us out. Chassis come wrapped in all sorts of nonsense, depending on the price. That can be a combination of static-shock-inducing velvet bags (looking at you, Corsair), hard polystyrene, designed to take a hit and break, or intuitively folded cardboard, providing about as much protection as a chihuahua in a knife fight. So, why is soft foam packaging better? Unlike hard polystyrene, it doesn't break on impact, and it provides far better protection and absorption than cardboard ever could. But, at the same time, it isn't used very often because of the higher costs involved in production. OK, good, we've got that out of the way.

The question, then, is: If soft foam packaging does so much more, why aren't other manufacturers using it? And if they aren't using it, why is Anidees using it here? The answer, you'd think, would be obvious: it's the tempered glass, clearly? The chassis itself is littered with it. Both the front and the side panels feature that smoky-looking reinforced stuff, ready to take any computer hardware and make it shine. At least, that's the theory. And with other manufacturers' cases being more durable than solid panels of glass, there's no need for it with those.

Out of the gates, the AI Crystal looks impressive. From a chassis manufacturer that hasn't been in the game for the last few years, the overall internal layout is great. You have a full-sized PSU cover, SSD mounts on the back of the motherboard, support for three 120mm fans in the front, subsequent airflow ventilation for them thanks to those nifty inch-long spacers between the side panel and the glass front case (glass isn't permeable, after all), plenty of room for cable management, and even a cable cover to hide those unsightly wires. Sounds good, right? A classy new aesthetic, solid internal layout, good modern-day features? Well, sort of. It's only when you start to take the case apart and examine it further that you begin to understand what sacrifices have been made to accommodate all of this at this price point.

CHOPPED CORNERS

The case we received for review had an interesting journey to our offices, which highlighted some of the corners cut. Our sample took a hit to the front-right side during transport, and although the glass remained intact, the grilled section designed to allow air into those front three fans shattered, leaving broken plastic fins everywhere. Then, while carefully removing the front panel, the two lower pins securing the front panel to the chassis broke off as well. On top of that, there's no tool-less drives here—everything is screwed down. The hard drive cages, made from thin steel, feel flimsy, and scratch as they slide in and out. The SSD mounts on the back of the motherboard tray are a similar affair. And the cable cover is a shiny, not-so-glamorous gloss polymer. Couple that with the basic fans, with transparent and exposed working motor, and the general sensation is one of disappointment. Everything is just a little too cheap, a little too cut back. The thought is there, the design features have been integrated, but corners have been cut to meet that price point, detracting from the very point of those premium glass panels.

That said, perhaps we should be approaching this differently. For the price, with the inclusion of the tempered glass and modern-day design aspects, this case is exceptional. It would be easy to build a beautiful system in here. Replace those stock fans with some aftermarket LED versions, slap an AIO cooler in there, a decent PSU with a custom cable kit, and some subtle lighting, and you'd be on to a winner. So, if you can live with the caveats and the frailty, the AI Crystal is a fine chassis. If you can't, well, you may want to look elsewhere. **–ZAK STOREY**

VERDICT 7

Anidees AI Crystal

+ **DIAMOND** Innovative design; good airflow; floor panels; fan controller.

− **QUARTZ** Cut corners; flimsy front grills; tool-required bays; plastic cable cover.

$130, www.anidees.com

SPECIFICATIONS

Form Factor	Full tower
Motherboard Support	E-ATX, ATX, mATX, M-ITX
5.25-Inch Support	None
3.5-Inch Support	x3
2.5-Inch Support	x3
Radiator Support	360mm front, 360mm roof, 140mm rear
Fan Support	3x 120mm front, 3x 120mm roof, 1x 140mm rear
Dimensions	18.7 x 8.5 x 19.6 inches
Graphics Card Clearance	16.1 inches
Weight	24lb

Logitech G Pro Gaming Mouse

Prodigious provider produces prowess

LOGITECH IS ON A ROLL at the moment, a slew of new products butting their way into existing niches, and carving out new ones with little mouse-sized hammers and chisels. Top of the fashion pile in mouse marketing meetings is to pretend your product is somehow tied to the professional gaming scene.

These esports mice are all very well, but when will somebody design a mouse for people who sit around all day surfing Reddit? Logitech—whose approach to branding is to write "PRO" in huge letters on the box, but not say pro what, and put out press releases featuring pictures of pro-gaming stars, cropped so you can't see what mouse they're using—does seem to have taken the approach rather to heart.

And it doesn't really need to. Logitech products are solid. They could be sold on their own merits, rather than some link to a minority pursuit, but the pull of the celebrity affirmation is strong. We heartily endorse this product and/or service.

Getting on to the mouse in question, the G Pro is unquestionably a mouse. It's part of the current trend for stripped-back products, with fewer features but better build quality. Why it still needs 16.8 million colors of LED lighting, though, is beyond us. Perhaps we're not very imaginative: Setting it to red could render it useful in a photographic darkroom, for example. You only get six buttons on this model, but they're well positioned, and all programmable using Logitech's generally excellent software, which will need an update to work with the new mouse—so beware if you're upgrading from an older Logitech model.

The casing is an identical swathe of black plastic in a classic rounded Logitech shape, unbroken apart from splits around the buttons, and the gaps for the dreaded lighting. It's unadorned with grippy panels or thumb-rests, leading to a spartan look, offset by a single shiny patch forward of the wheel. The rolling disc itself is pleasingly broad, deeply ridged, and taking a positive effort to spin from one notch to the next. Thrust it back and forth fast enough, and you even hear it pass over whatever mechanism tries to stop it. There's nothing special about it, it's just a plastic circle without a rubber tire or soft-touch coating, but it's well designed and satisfying to use.

And that could be the summation of the G Pro, as feel is everything for a peripheral that spends so much time in your hand. It's engineered to be extremely accurate, with a PMW3366 optical sensor, the absence of any smoothing or pixel rounding, and some clever metal springs under the main buttons; the nicely braided cord is a decent length; and it feels good in the hand.

It brings forth a different type of feel, too, exemplified by a quote from a *CS:GO* pro in the promotional material. He says that upon switching to the G Pro it "felt like" he was landing more shots. No stats are given to back this up; it's provided as a fact purely on "feel" alone. If you're coming to this mouse from something older, and maybe using it on a high-res screen at the top end of its sensitivity, and skipping over the question of why you skimped on a mouse when building your rig, there's a chance this kind of quality build will allow you to land more shots. If you're already landing a lot, then maybe the feeling that more are connecting is good enough.

You'll also find the PMW3366 optical sensor in Logitech's cheaper G Daedalus mouse, so anyone looking at the Pro will need to decide whether the Daedalus's slightly awkward shape is enough to send them up the range. If it is, the G Pro will not disappoint you. **–IAN EVENDEN**

VERDICT 8

Logitech G Pro Gaming Mouse

+ PROVOCATIVE Built for accuracy; solid body; well-placed switches.

− PROTOZOAN Only six buttons; no additional features, except lighting.

$70, www.logitech.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	200–12,000 dpi
Sensor Model	PixArt Technologies PMW3366
Polling Rate	1,000Hz
Programmable Buttons	6
LEDs	One zone, 16.8 million colors
Cable Length	6 feet
Weight	2.9oz

SteelSeries Siberia 350

Do we see acceptable headset LEDs?

STEELSERIES HAS an almost legendary reputation for providing well-designed, well-rounded peripherals. Peripherals that cater to a wide variety of play styles and levels of enjoyment. Its headphones, in particular, have always shone brightly through the muddiness that is the world of gaming audio. Dashing aside overpowering bass and muffled treble to provide crisp, clear, well-rounded clarity. Indeed, it was the first company to innovate on a truly seamless wireless headset experience, in the form of the original H Wireless, featuring swappable batteries, a rugged portable design, and a charging dock that made the competition quiver in stark contrast. But this landscape has changed, and SteelSeries's design ethos has shifted from the rugged yet classy aesthetic of the H series and Sensei, to the more outrageous and conceptual design of the Rival and Siberia.

And that's exactly what we're looking at today. Ladies and gents, we give you the Siberia 350s! At $115, these USB 7.1 surround-sound RGB cans are encroaching on true audiophile territory. But the question is: Can they compete with the likes of Audio-Technica's M40s and M50Xs, or even the prodigal sons of the audio world, Kingston's HyperX Clouds?

Well, to start, they have a frequency response ranging from 10 to 28,000Hz, and a built-in USB soundcard, all powered by 50mm neodymium dynamic drivers. In short, they should be quite impressive going by that alone.

COMFORT AT A COST?

Out of the box and on the noggin, these cans are incredibly comfortable. The padding lining the top of the auto-adjusting head cushion is supple and soft. It's not too hot, nor does it particularly wear on you over long periods of time. That said, it is a little worrying that there are only two little strips of wire holding the band to the headphones themselves. If you were accidentally to sit on these, we can't imagine it would take very long for them to break. On top of that, this is the only time when RGB LEDs are acceptable in a pair of headphones. You're still not going to see them, but the fact that the Siberia 350 isn't wireless means you're not going to be wasting battery life on flashy lights that only your partner will glimpse.

Sound quality is a mixed bag. At this price point, the treble and the upper mids are exceptionally solid, very well rounded, crisp, and enjoyable. What lets the 350s down a tad is the lower mids, merging on to the higher end of the bass. It just feels a touch too empty, especially in classical scores and orchestral. Synthetic music, on the other hand, is a much more enjoyable experience—you still get that hollow lower mid echo almost, but it's generally much more enjoyable.

You can really hear that extra frequency response SteelSeries has packed into these drivers; it's just a shame that the lower mids fall so flat in comparison to the rest of the soundstage. Now, this generally wouldn't be such a huge deal for a headset at this price—however, with SteelSeries's reputation, and its 5HV3s coming to mind, it's a little disappointing.

As far as setup goes, we ran these at stock, not adjusting the EQ in SteelSeries's Engine 3.0 software, and ran for the hills when it came to DTS. Just slap the Engine profile into Music mode, and keep it there.

Ultimately, the Siberia 350s are a unique and interesting take on a gaming headset at this price point. The extra frequency response helps keep the trebles and the clash of swords crisp and sharp to the ears, without verging on sibilance, and their stylish design will ensure you own that next gaming event and LAN, especially with those RGB LEDs flickering away. However, we just can't let them off when it comes to the mids—it detracts from the entire aural experience, and leaves us walking away with a sour taste in our mouths. **–ZAK STOREY**

VERDICT 7

SteelSeries Siberia 350

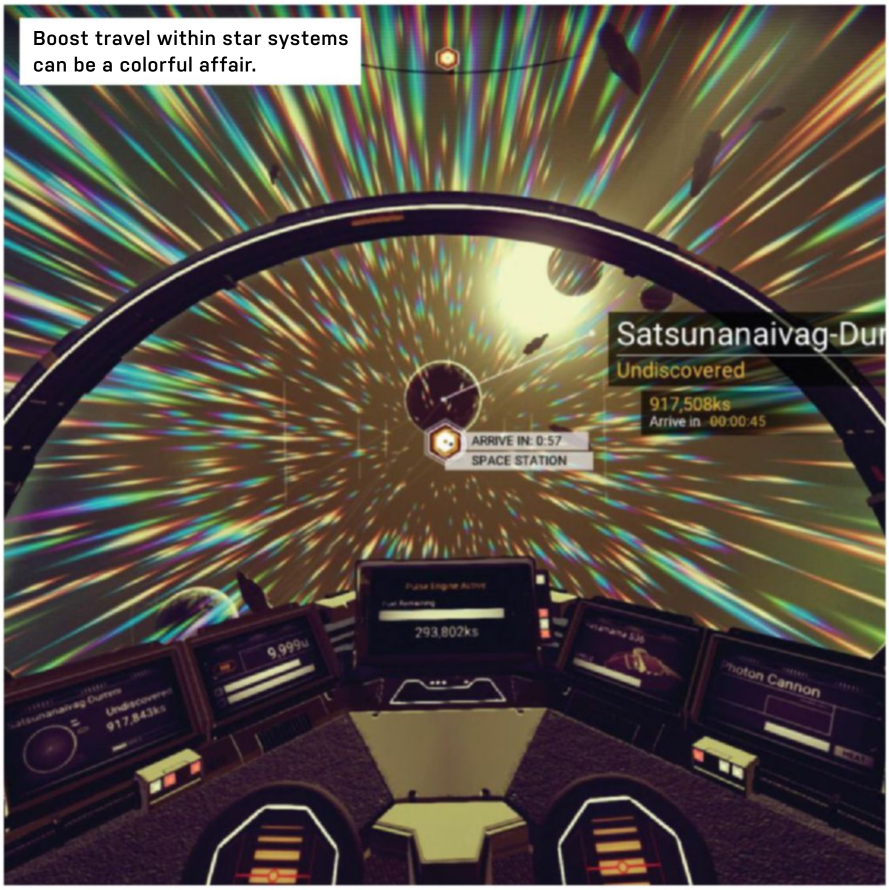
+ HUSKY Lightweight; comfortable; innovative design; non-impacting LEDs; OK soundscape.

− PUG Missing mids; doubtful durability.

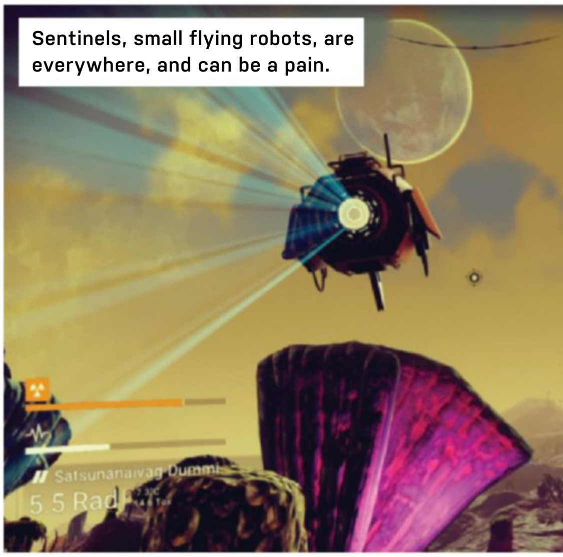
$115, www.steelseries.com

SPECIFICATIONS

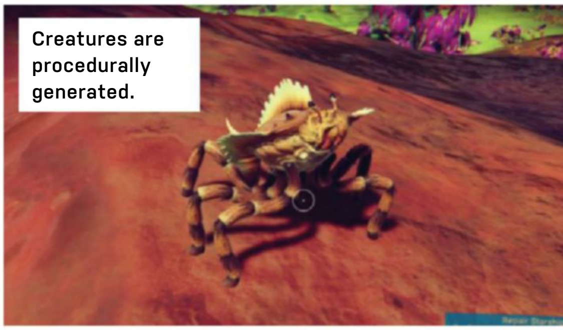
Driver Type	50mm neodymium dynamic
Impedance	5 ohms
Frequency Response	10Hz–28,000Hz
Design Style	Semi-open
Microphone Type	Retractable unidirectional
Connectivity	USB
Weight	10oz
Cable Length	5 feet



Boost travel within star systems can be a colorful affair.



Sentinels, small flying robots, are everywhere, and can be a pain.



Creatures are procedurally generated.

No Man's Sky

A long time ago at the final frontier...

A QUESTION THAT'S BEEN ASKED since the release of *No Man's Sky* has been: "Is this the game we saw in the trailers?" The simple answer is no, it's not. When the definitive history of videogames is written, an entire chapter will be dedicated to studios massively over-promising in their trailers, and *No Man's Sky* isn't even the worst offender. Irritating bug-hunt *Aliens: Colonial Marines* looked amazing in video form, while the reality of *BioShock Infinite,* although a good game, was different from that portrayed during development, with many abilities and locations removed.

If, by any chance, you're still holding off buying *No Man's Sky* thanks to the Internet's downcast reaction to its launch, then know that it's definitely worth playing—there just might be fewer herds of sauropod-like creatures being hunted by predators from the trees than you were expecting.

What you've got here is essentially a PlayStation port rather than a game made for PC. The oddness of the controls gives it away, along with a save system that needs to be triggered by getting in and out of your ship, or manually at outposts. Why it's necessary to hold the mouse button down to fill a small meter before an option is selected is beyond us, but it's perhaps even odder that a PS4 game should use a PC-style wandering cursor in the first place, rather than just snapping between objects.

Graphics options are restrictive, although at least there's an FOV slider, while the controls are maddening if you don't use a pad. Even if you do, there's no invert-Y option that we could find. We're not serial inverters—don't get us wrong—but some games, particularly those featuring, say, spaceships, are crying out for airplane controls. One thing we didn't have a problem with was performance, the game running smoothly in 1080p on a GTX970 and quad-core i7 combo. It didn't crash, and our saves didn't go corrupt. There's some pop-in, though, and objects visibly fizz from one form to another as you approach them—the dissolve and reform actually making it more noticeable, as it catches the eye.

No Man's Sky isn't an action game, although there's action to be found—Sentinel drones harass you for mining in a way they consider offensive, wildlife attacks without warning—it's really more in the vein of a survival and exploration game, perhaps the universe's most spread-out walking simulator. The basic loop is that you collect resources and discover new things in order to fuel your spacesuit, multitool, and starship. Once you've exhausted an area, you move on and begin again. Eventually, you'll be able to upgrade your starship so it can hold more inventory, which means you'll be able to make more money. There's a plot thread pulling you along, and plenty of encounters with mysterious life forms, but you're welcome to wander off the path and find your own fun. Life is plentiful in the universe, and you can spend tens of happy hours simply wandering around, just as long as you're prepared to take it slowly and don't mind the repetition that begins to creep in, thanks to the procedural generation system.

Your hand isn't held, and in a game with so many complex systems, this can be a problem. We're not expecting *Dead Space*-

50u
Rasamama S36

Life, such as this space-faring civilization, is common in the galaxy.

Plant life is common, even on otherwise barren planets.

Flying in your ship is often the quickest way to get around.

style graffiti that explains the combat system's main points, but when your starting planet is so radioactive it's killing you, and you're desperately hunting for "isotopes" to fuel your life support, a certain degree of panic can set in. Discovering new areas and species earns you cash (although we'd argue they're not undiscovered, because there's generally an outpost with signs of life there, if not an actual alien sitting at a table). Once you've discovered and named a few of these, flown up to orbit to blast asteroids for fuel, and got some upgrades (improving our multitool twice in short order felt great), you'll feel like the galaxy is your own personal playground.

STIFF COMPETITION

No Man's Sky also allows something we'd thought had been excised from modern videogames: the ability to unknowingly completely stiff yourself. Parking on a floating rock, then dropping down to investigate an outpost led to a frustrating inability to jetpack back up to the ship, and a reload. Flying over a planet lacking in mineable resources meant that we couldn't land, because there wasn't enough juice in the launch thruster to take off again. And if your mining beam runs out, you'd better have some plutonium for it in your inventory, because while it is possible to get some without mining, such opportunities are few.

It's always going to be tempting to compare *No Man's Sky* to *Elite: Dangerous*, but it's not a fair comparison. The two games happen to feature spaceships, but are otherwise quite different, with *Elite's* planets being airless rocks, while *No Man's Sky* would be nothing without its worlds. Where they do overlap, however, is in their after-launch support. *No Man's Sky* has, at the time of writing, already had a major patch, 1.07, and Hello Games mentioned "future free updates, which will improve, expand, and build on the *No Man's Sky* universe" in a development update. Which means that next year the game could be a very different experience.

We have to review what we're given, however, and at the moment *No Man's Sky* can be a slow and sometimes frustrating experience, often repetitive, but with just enough sparks that make you believe there's something great out there, if only you had enough Vortex Cubes. Perhaps traveling to the next system or just to another planet will open it up, and even if it doesn't, you'll find everything you need there to try again.

So you hop from planet to planet, system to system, always in search of the unknown, earning resources and upgrades, learning new alien words, interacting with baffling monuments, the tug of exploration always pulling you onward. **–IAN EVENDEN**

VERDICT
7

No Man's Sky

+ **ASTRONAUT** Huge galaxy to explore; vast amounts of upgrades; lots to see and do.

− **COSMONAUT** Can get repetitive; easy to kill yourself; currently quite shallow.

RECOMMENDED SPECS Intel Core i3, 8GB RAM, Nvidia GTX 480 or AMD Radeon 7870.

$60, www.no-mans-sky.com, ESRB: T

Breach mode is cleaner and simpler than the main game.

Deus Ex: Mankind Divided

Adam Jensen returns, augmented by political action

THE *DEUS EX* SERIES is in a strange place. By choosing to make the later games prequels, Eidos Montreal was presented with the paradox of making them closer to our time, but necessarily more primitive than the original game. Yet, given the rate of technological advance, the first game already looks like an artefact from another timeline. When it was created, back in 2000, a cutting-edge cell phone looked like the Nokia 3310. In *Mankind Divided's* time, a cell phone is built into the protagonist.

In the previous game, *Human Revolution*, cyborg Adam Jensen discovered a plot to take control of augmented humans through their implants. While foiling it, a signal was sent that drove all augmented humans into a killing frenzy. In *Mankind Divided*, it's several years since the incident, and augmented humans are now seen as dangerous second-class citizens.

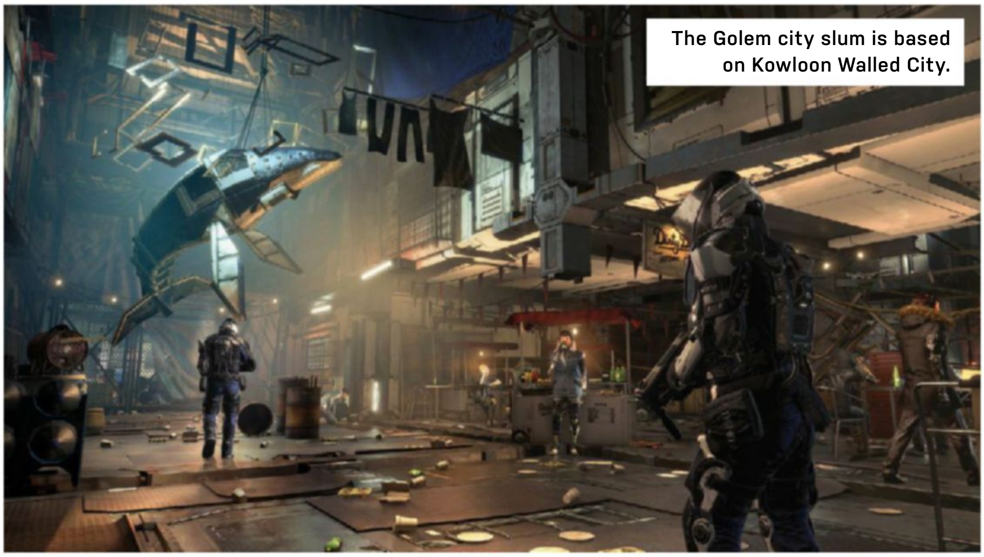
Jensen is now working for Interpol as an agent, running down terrorists and smugglers of all stripes—but also operating as a double agent for the Juggernaut Collective, a group of hackers aiming to keep tabs on the world-controlling Illuminati. An operation in Dubai and a terrorist attack on a train station leave Jensen injured, and a new plot to follow up. Who's arming these terrorists? Is it the augmented, the Illuminati, or someone new?

PLAYING FAVORITES

Like *Dishonored* or *Thief*, the *Deus Ex* games support multiple play styles, being almost a first-person sandbox. For every challenge the story throws up, there are multiple routes—violent, stealthy, talky—to choose from. Adam's upgradeable special powers and many weapons (lethal and non-lethal) add to that huge variety. Depending on the path you choose, Adam can see through walls, fall from great heights, breath poison gas, defeat anyone in hand-to-hand combat, lift huge weights, hack any device, or become invisible. He's basically a build-your-own superhero for the near future, and he's rather enjoyable to control.

That's lucky, as the Prague of 2019, where Adam is based, and where much of the story takes place, is a delight to explore. It's a genuinely city-center-sized hub, with every part, from the basements and sewers to the billboards and rooftops, packed with side stories and character. As you walk across its cobbles, people, dioramas, architecture, and quests compete for your attention on every level. Vents, locked doors, balconies, and guards all tempt you away from your Interpol-assigned tasks, and distract you from the misery the augmented are suffering on the street. Your X-ray eyes see through every wall to spot riches galore. It's a wonderful world.

Given that size, using the underground train network is a necessity—but it's also a key place where you experience the anti-aug feelings that are a core part of the game's storyline, given how carefully segregated the city is by heavily-armed police, and how distastefully the unaugmented humans look at you when you choose to ride in their carriage. Much of the storyline is focused on the prejudice suffered by the augmented, with parallels drawn with both the treatment of Jews under Nazism and Imperialism, and with the current Black


The Golem city slum is based on Kowloon Walled City.

Conversation options can be a matter of life or death.

Either Jensen is planning something big or tying his lace.

Your maintenance guy, Koller, certainly loves his work.

Lives Matter protests. With such a delicate subject to handle, there are inevitable missteps, but the writers and designers have mostly built the world with care, and there are hard moral choices to be made throughout the game's wandering plot.

Adam himself has some new tricks up his sleeve, down to an unexpected upgrade in between the two games, which provides another plotline for him to chase down. These new upgrades are revealed after the terrorist attack, and justify his powers being reset from the previous game. Each of these new powers requires you to permanently disable one of your older powers, so you only have a few of them active at a time.

The new powers are nicely placed to fill in gaps in your arsenal, inspired perhaps by *Dishonored*. A Tesla gun is very short-ranged, but can automatically knock out up to four enemies with every shot, and the Peps gun similarly can clear a corridor non-lethally, while you can now pin enemies to walls (lethally) by firing nanoblades from your arms. The Icarus Dash allows Adam to cross large gaps easily, Focus enhancement briefly slows down time, and Titan temporarily makes you invulnerable. Finally, Remote Hacking allows you to access cameras, keypads, drones, and mechs from any distance, and is essential.

SMOOTH TALK

In line with the powers, other minor annoyances have been smoothed. Power and health slowly regenerate when you're out of combat. Both can be supercharged—by biocells and health packs—in advance of dangerous situations. The boss battles are similarly reduced in number and improved in flexibility, compared to the first game's grinding combat, and can be avoided completely if you're careful.

That said, the control and combat systems are still clunky compared to a traditional first-person shooter—a death in combat is often a function of a control failure. And, unlike the first game's city-hopping, Adam spends the vast majority of his time in Prague, beautiful as it is.

Finally, the game comes with a secondary mode—Breach—focused on hacking into a major in-game bank. It's a solid virtual-reality version of the combat and stealth sections of the main game, replete with microtransactions. That makes it rather throwaway, though it's a fine playground while you wait for the inevitable story DLC.

It's fascinating to see how Eidos Montreal is creeping more slowly toward Ion Storm's original game, setting up the conditions for the world of 20 years ahead. This latest is a solid next step on the path, which neatly dodges the legacy soap-opera storylines that beset the *Assassin's Creed* games, even if it leaves many storylines unfinished to bait you along. **–DAN GRILIOPOULOS**

VERDICT 8

Deus Ex: Mankind Divided

AUGMENTED Courageous; eloquent; noir.

FRANKENSTEIN Retread; controversial.

RECOMMENDED SPECS Intel Core i7-3770K or AMD FX 8350 Wraith; AMD Radeon RX 480 or Nvidia GTX 970; 16GB RAM; 55GB storage.

$60, www.deusex.com, ESRB: M

LAB NOTES

JARRED WALTON, SENIOR EDITOR

Zen and the Art of CPU Manufacturing

We need AMD, Zen, and a good price war

THE CPU SCENE has been in a rut for several years now. Intel's regular tick-tock cadence (now process-architecture-optimization) has produced incremental improvements each generation, and AMD has tried to keep pace. Unfortunately, AMD started at a performance deficit with K10, and Bulldozer didn't help matters.

If you want the fastest and most efficient CPU in your PC right now, Intel wins, period. But that may not be the case once Zen arrives on the scene, because AMD is taking another shot at the performance processor market. Designed to scale from mobile up through desktops, workstations, and servers, Zen certainly looks promising, with features such as SMT (symmetric multithreading), improved IPC (instructions per clock), and a completely reworked pipeline. Moving to a competitive 14nm FinFET process is also a huge jump from Vishera's 32nm SOI.

This is the first time in nearly a decade that AMD has a chance to go toe-to-toe with Intel. AMD showed eight-core Zen taking on a Broadwell-E i7-6900K, with both running at identical 3.0GHz clocks, and Zen came out just a hair faster in a Blender benchmark. That may be only one benchmark, but it's a good start—I've seen Blender tests where AMD's FX-8350 was about 30 percent slower than a Core i7-4770K.

Taking on the i7-6900K shows Zen has potential, but what I really want to see is a quad-core APU with performance rivaling the i7-6700K, paired with a GPU equal to the RX 460. I'd still want discrete graphics (hello 4K gaming), but having a compelling alternative to Intel would be great.

Can AMD do it? I don't know, but I certainly hope so!

Zen may not revolutionize CPUs, but AMD is banking on its success.

ALAN DEXTER

Executive Editor

My opinion of Windows 10 is in a state of flux. One day I think it's the best Microsoft OS to date, and the next it makes me want to reach for my old Windows 7 install. I'm generally impressed by how it behaves, but erratic restarts and bungled updates can be incredibly frustrating.

Right now, I'm particularly down on Microsoft's latest, and it's a problem that may not go away. I recently had to upgrade the graphics card in one of my machines, due to an annoying hardware failure. Long story short, it meant replacing the motherboard as well, and because I was performing such a major overhaul, I decided to upgrade the processor while I was at it. And the memory.

Windows 10 initially took these changes in its stride, but then a message appeared, telling me that Windows needed activating. Odd, but I've jumped through enough Microsoft-branded hoops in my time to take it in my stride. A quick click of this message, and I'm staring at the Activation screen, with the option of using the Activation Troubleshooter (introduced in the Anniversary Update, no less). Sure enough, at the bottom of this page, there's a link that seems to fit: "You recently made a significant hardware change." Only that's where the trail ends, because apparently my install isn't legit. And it absolutely is.

The next step is to contact Customer Support, but right now I'm contemplating installing Ubuntu 16.04, and running my few games in WINE. There's also that Windows 7 installation disc.

Editors' Picks:
Digital Discoveries

Tuan Nguyen, Editor-in-Chief, and Zak Storey, Staff Writer, reveal their latest tech loves

SCHIIT JOTUNHEIM

One of the best kept secrets in the audio community is Schiit Audio. It makes some crazy good enthusiast audio equipment with a no BS attitude. No jargon, no gimmicks; just straight up quality.

The company focuses on products for headphones, but some of its gear also works with powered studio monitors. For the most part, though, if you're a headphone lover, you'll dig its line of DACs and amps. Recently, however, Schiit released a product called the Jotunheim, and in my opinion, it's a perfect high-end replacement for any internal or external PC soundcard product.

The Jotunheim includes a high-quality DAC, pre-amp, and headphone amp in one small unit. Best of all, it supports single-ended and fully-balanced connections, which makes upgrading to high-performance monitors perfect. The audio quality is amazing, and unmatched by any traditional PC audio solution. I've been testing the Jotunheim with several mainstream and high-end headphones, and have not come across a single headphone where the little Schiit couldn't deliver.

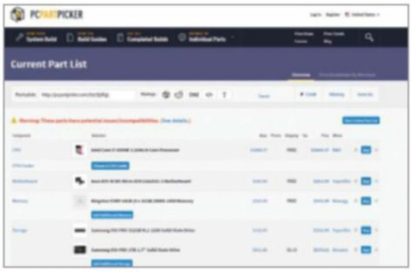
Best of all, Schiit allows you to configure the Jotunheim with modules. If you don't need a DAC, you don't need to have one.
$399, www.schiit.com

PC PART PICKER

I don't think we've ever spoken about PC Part Picker. As far as websites go, it's right up there for convenience. I use it almost daily, for price checking, system speccing, a multitude of things.

It acts as a hub for PC enthusiasts, especially those looking to piece together a new system. Here you can set out what you want to build, and get a final price for the lot based on the best prices from all the online retailers in your country. It's not 100 percent accurate—occasionally, you need to search for some products yourself on Amazon, Newegg, or Google to find the best price, and newer products and more miscellaneous stuff often aren't on there (here's looking at you, Samsung SM961 M.2 SSDs). But 99 percent of the time, it's solid for pricing up the average build. It's also great for rookies and people looking to get back into PC building, as it only lets you choose components that are compatible with one another. It also gives an estimate of how much power your system will draw.

There are also forums, featured builds of the month, build logs—you name it, it's on there. It wouldn't be impossible for us to do our work here at *Maximum PC* without it, but it would take us a hell of a lot longer.
Free, www.pcpartpicker.com



GEEK TESTED & APPROVED

Rode PSA1 Boom Arm

LAST MONTH, I set off on a personal project. It's a combination of my desire not to have to swap out to a gaming headset whenever I want to play online, and my plan to develop a home setup that I can produce YouTube content on. We still have a Razer Seiren Pro in the office, so I figured I'd grab a decent boom arm.

I'm one of Razer's harshest critics, but the Seiren Pro? It's truly a thing of beauty. After having a chat with our contacts at Razer, they suggested I invest in a Rode PSA1 swivel boom arm. It's moderately inexpensive, but you need to purchase one of Razer's Seiren Shock Mounts to attach it to the arm. Setup was relatively simple. The PSA1 has two desk mounting options: Either you attach it to your desk with the included clamp, or use its pre-threaded desk insert. Then it's a case of slotting the bottom of the boom arm into the hole of the clamp/thread, and you're all set to attach your mic. Fortunately, the PSA1 also came with a 3/8-inch adapter that I attached to the top thread of the arm, after which you mount your shock mount and mic to the boom, route the cable through the Velcro cable straps, and that's it.

How is it? Pretty darn good. The arm is spring-loaded, so it requires the weight of the mic to hold it down correctly, but once you've got a mic attached, it's flexible enough to position any way you like. It does have its limits, especially with the heavier Seiren at lower angles, but it's solid, looks classy, and removes an unsightly mic and its cables off my desk, for use only when I need it. **–ZS**
$99, www.rode.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON…

> Hybrid Sleep Mode
> TV or Monitor?
> Backup Software

Sleep Safely

The article "Supercharge Windows 10" incorrectly states that the hibernation file is not used by Sleep mode. Windows uses a hybrid sleep mode that relies on the hibernation file in the event the PC loses power. But I bet almost everyone at the magazine knew that…. Great magazine by the way.

–Robert Tortorelli

CONTRIBUTING WRITER NICK PEERS RESPONDS: Technically, you're correct, in that Windows offers a hybrid sleep mode that uses the hiberfil.sys file to store the contents of RAM during sleep as well as hibernation, so if there's a power failure, you don't lose any work.

But, you don't need it. If you're low on disk space and happy to forego this additional protection, you can still put your PC to sleep. I know this because I disabled the hiberfil.sys file and my PC still happily goes to sleep. It's the sleep we all knew and loved from years gone by, as well. Everything but RAM gets powered down, so still low power mode. To be honest, if my PC goes to sleep, it's for temporary purposes. If a power outage occurs, I'll start again. I wouldn't have expected my PC to magically go back to where I left it.

Hybrid sleep is slower, too—and not a magic bullet. It takes longer because the contents of RAM have to be written to the hard drive when you put your PC to sleep (that step is bypassed when hibernation is disabled), and if power is lost during that process, you lose your data anyway.

Side note: this hybrid sleep mode is enabled by default on desktops, but disabled by default on laptops. As they have power backup courtesy of the battery, it's redundant.

Big Screen Dream

I'm thinking about ditching my TV for a large-format (40-plus-inch) computer monitor. My TV mostly gets used for movies and games played on a PC, and monitors offer IPS panels and very low latency, at relatively little cost. There just aren't a lot of reviews that focus on the usual PC enthusiast shenanigans. Would you guys be interested in doing a roundup of large-format displays? I'd love to know how suitable they are for a living room media/gaming PC setup, and how you overcome any challenges.

–Lee Rittenhouse

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: This is a great idea, as the line between TVs and monitors is blurring more and more. The way we watch TV and movies has changed, too. So, we accept your challenge: Consider this a promise for a future roundup.

Chess Your Facts

While I enjoyed the article "Supercomputers vs. PCs vs. the Human Brain" in the October 2016 issue, I noticed a slight factual inaccuracy. Mr Walton claims that the match that took place in New York in 1997, between Deep Blue and then World Champion Garry Kasparov, was "the first time a computer had been able to defeat a Grandmaster chess player." This is incorrect.

The first time a chess computer beat a human player at classical time controls was in the Software ToolWorks championship in 1988, where the late Danish Grandmaster Bent Larsen lost to Deep Thought, the predecessor to Deep Blue. The alternate meaning of the sentence, that this was the first time a World Champion had been defeated by a computer, is also false. Garry Kasparov lost to Deep Blue in Game 1 of the Philadelphia 1996 match.

I apologize for the pedantry, but chess players are nothing if not precise.

–Connor Eickelman

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Thanks for clearing that up—corrections like this we can live with. And we're not even going to mention the Mechanical Turk, because that was kind of cheating.

Built for Speed

I am interested in building a computer for flight sims and auto racing. Would the build you highlighted in the October issue for $699 be OK for this? **–Scott Hondros**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: My initial response is to point out that our $699 rig was designed with its low budget very much in mind, and compromises had to be made to hit that price point. When it comes to simulators, you want the most immersive experience possible, which tends to favor more high-end

↘ submit your questions to: comments@maximumpc.com hardware. You don't want to drop frames, or be forced to run at lower settings.

However, some of the more recent simulators aren't as demanding, and the likes of *Project Cars* and *Microsoft's Flight Simulator X* have low minimum system requirements. So, as a starting point, and assuming you're on a tight budget, it isn't a bad place to start. Be warned, though: Once you've been hooked, those steering wheels, HOTAS joysticks, and pedals can soon eat into your cash reserves.

On Reflection

I have several questions about your recommendation for using Macrium Reflect for all of your backup needs. I have always done my data backups manually or with Synctoy. I used Acronis True Image for years but never installed it. I purchased the disk and booted to it to make images of my system. I have restored with it many times, but I only image the C drive, not the system partition.

The Windows 7 System Image tool is in Windows 10, and after installing Macrium Reflect, I see they both image the C drive and the system partition. This concerns me, as with a corrupted image, you could hose your system partition. I also found you could boot with the Macrium Reflect Win10PE boot disk and create an image, checking only the C drive.

For images only, is Windows 7 System Image as good as Macrium Reflect? Is it better to create the images from the boot disk, instead of with Win 10 running? Do you agree with not imaging the system drive? Once you have created the Win10PE disk with Macrium Reflect, can you uninstall it, if you do not use it to back up data but create images only, as you could with an Acronis disk?

I know with all of the testing that *Maximum PC* does, that you have restored with pretty much every method many times. Please set my mind at ease.

–Steve Davis Sr

CONTRIBUTING WRITER NICK PEERS RESPONDS: Long story short: I've been using Macrium for years, and trust it implicitly. Here's why:
1. Unlike Windows, you can verify drive images after they've been created (and instruct Macrium to verify images automatically).
2. Macrium now supports differential drive images, which allows you to keep multiple images in a fraction of the space required by Windows, which creates a full drive image each time.
3. Macrium works better with multi-partitioned systems, as you choose what to back up—the full drive, or just the partitions needed to boot Windows.
4. I like the rescue media. It's Windows PE-based, and contains boot repair tools on top of the image creation and restore tools. You can install it to the hard drive as a bootable partition, too—entirely your choice.
5. Unlike Windows, I can browse the drive images by mounting them as virtual disks in Windows, so if I need to recover an individual file from the image, I can do so easily.

Macrium Reflect comes in both free and paid-for editions. The point of recommending it in the article is that it's a superior alternative to Windows for all the reasons mentioned above. If you've already got another solution that works for you, there's no need to use Macrium—stick with what you know. But, personally, I prefer Macrium to Acronis—its user interface gives me far more flexibility over my backups, and doesn't try to push an expensive cloud storage subscription (which I consider wholly inappropriate for a large drive image) on me either.

[NOW ONLINE]

THE BEST HIGH-END HEADPHONES

After months of testing and retesting more than 30 sets of popular headphones, including over-ear open and closed models, affordable headphones and high-end audiophile headphones, editor-in-chief Tuan Nguyen comes up with the best headphones that deliver exceptional audio performance for gaming, music, and movies.

You can read the full story online at http://bit.ly/2c8zJtg.

RAID Fail

I read the comment by Ben Pearman in the September issue and I was a little concerned, because I have a large video collection of movies and TV shows on a RAID 5 array consisting of five Seagate 3TB drives on a DATOptic SPM 394 controller. Yesterday, it went down and complained that drive #5 had failed. I pulled the drive and tested it, and sure enough, it was dead as a doornail. I replaced it, and it took 6.5 hours to rebuild, but viola—all my data was intact, so I think I will stick with this setup for now.

I would love to hear more about the pros and cons of different types of arrays. I also have the same setup on a Windows Home server with the same data, just in case, and to stream on my network with Plex, which works with my cable boxes. I'd like to see more on that, too.

–Tom Martin

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Lengthy rebuild times are common for modern hard drive capacities, and it's one of the reasons that RAID 5 is frowned upon in some quarters, as is RAID 6. That RAID feature is definitely on the cards, though, because we've had plenty of questions on the back of Ben's letter. However, we've been inundated with a slew of new technologies recently, and we wanted to give those releases lots of space, which is why RAID hasn't made it into a feature.

To allay your fears until that feature lands, though, you won't have to dismantle your RAID just yet—just as long as you have a backup, in case something goes wrong. You do back up your videos don't you? Good, good.

Future

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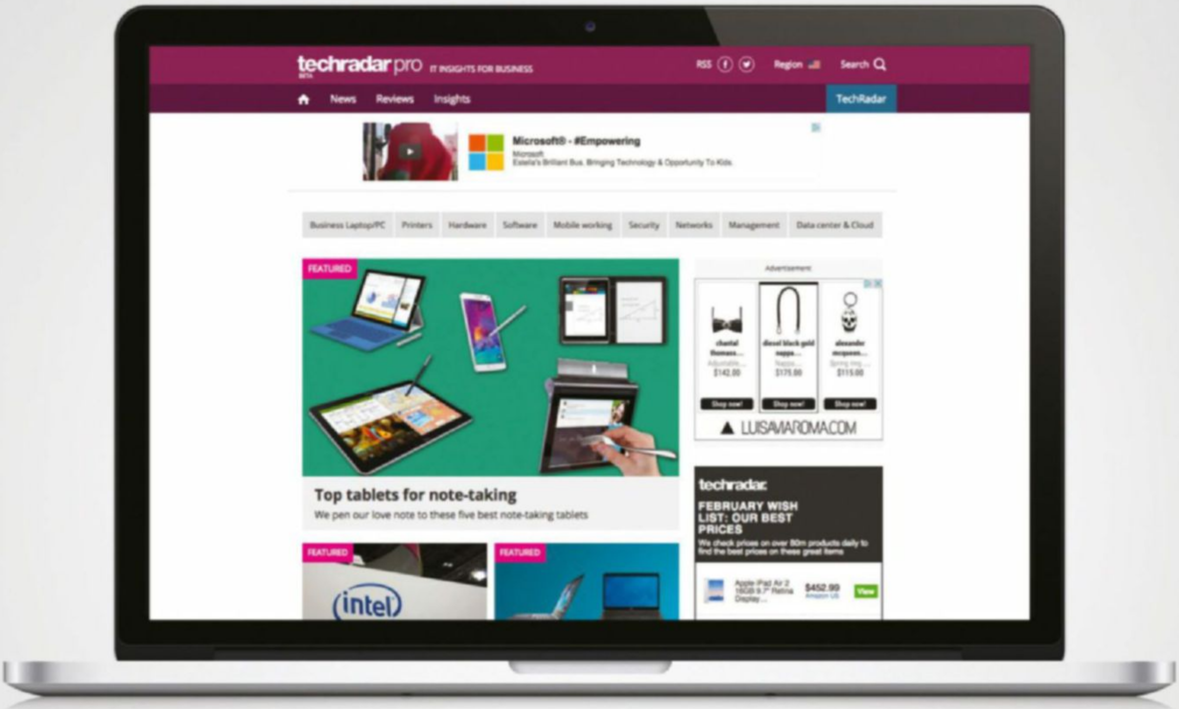
IT INSIGHTS FOR BUSINESS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THE BUILDS

BUDGET

INGREDIENTS

PART			PRICE
Case	Thermaltake Core V1		$49
PSU	EVGA SuperNOVA 550 GS	**NEW**	$83
Mobo	ASRock H170M-ITX	**NEW**	$85
CPU	Intel Core i5-6500		$205
GPU	Zotac GeForce GTX 1060 Mini 3GB	**NEW**	$200
RAM	8GB (2x 4GB) G.Skill Aegis DDR4-2133		$37
SSD	256GB SanDisk X400 2.5-inch SSD	**NEW**	$86
HDD	1TB Seagate Barracuda 7,200rpm 3.5-inch SATA		$50
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit		$16

Approximate Price: $811

PRICES, ESPECIALLY FOR GRAPHICS CARDS, are fluctuating like crazy. Couple that with the numerous offers on 2.5-inch SSDs, and now is definitely the right time to treat yourself to a budget build. We say "budget," but this thing is a monster—that new mini GTX 1060 sitting inside will happily munch up AAA titles for breakfast, even this 3GB version. Unfortunately, we lost a few good products this issue: The EVGA G2 550W PSU has made its way out in favor of the SuperNOVA 550 GS, and the 240GB SanDisk Ultra II gave way to the X400 in its stead. After much debate (literally seconds), we also dropped the AC variant of ASRock's H170M-ITX, as it adds little to gaming potential. That aside, the biggest upgrade you could do would be to swap out Linux for Windows 10, which offers loads more options for gaming—thanks to driver updates alone, you're looking at an fps increase of 30–40 percent—but it would take the price up to $895.

MIDRANGE

INGREDIENTS

PART			PRICE
Case	NZXT Manta		$130
PSU	EVGA SuperNOVA G2 650W 80 Plus Gold		$90
Mobo	Gigabyte GA-Z170N-Gaming 5		$161
CPU	Intel Core i5-6600K		$240
Cooler	Corsair H100i v2		$105
GPU	Gigabyte GeForce GTX 1070 Windforce	**NEW**	$400
RAM	16GB (2x 8GB) G.Skill Ripjaws V Series DDR4-2400		$70
SSD	250GB Samsung 850 EVO M.2		$110
HDD	Western Digital Black Series 1TB 7,200rpm		$75
OS	Windows 10 Home 64-bit OEM	**NEW**	$100

Approximate Price: $1,481

WE'RE STILL ON A PRICE HIKE THIS MONTH. It's been tricky to balance this build, but we've managed to scrape some savings together here and there, to ensure that the overall price has only increased by $7. Not too shabby, then. So, where's the money been saved? Well, we saved $10 off the GTX 1070 by opting for Gigabyte's stock Windforce variant instead, and went for an OEM 64-bit copy of Windows 10 Home, as well, saving another $10. Doesn't sound like much, but when the price of the mobo, processor, cooler, memory, SSD, and HDD all increase at the same time, it's a miracle we managed to keep that difference so low. There's a great deal going on with EVGA's Stinger Z170 ITX motherboard—it's a little black number, with a rear I/O cover, but it doesn't come with a PCIe M.2 port for storage, which does kinda suck, but a $40 reduction in price made it a tempting offer. Look out for deals and bundles like this if you plan to purchase a new system.

TURBO

EVEN MORE ADJUSTMENTS. Yep, this month we followed the theme of sticking with that single card. As Nvidia seems to be stepping away from SLI solutions, it makes sense to keep to a single card here. Unfortunately, the Sea Hawk X we featured last issue has had its pricing bumped back up to the flat $900, so we went for the standard non-X variety instead, saving us a sweet $150 to spend elsewhere. And, let's be honest, it's not that difficult to crack an overclock on a GPU nowadays (see our feature on page 26), and it's certainly not worth that amount of money, either.

On the back of that massive saving, coupled with price reductions on both the Asus X99-A II and the EVGA PSU, we decided to splurge a little and go for Intel's 750 1.2TB PCIe SSD. OCZ's 1TB PCIe M.2 drive has a habit of throttling, and the speeds aren't that great. With a full-sized PCIe card, you get better performance, more storage, and less chance of the memory controller throttling due to the attached heatsink. So, that's a win in our books. And then, on top of that, we shaved another $10 off the Windows 10 OS simply by buying it OEM, as opposed to downloading it from the Microsoft store. Problem solved then, right?

What is a little worrying is that this price hike trend seems to be continuing—although we are scraping deals here and there, it's not enough to continually drive down the overall price each issue. Hopefully, Black Friday and Cyber Monday should bring some much-needed respite to the market, and shatter those price ceilings we're seeing on some of those component parts, too.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Evolv ATX		$170
PSU	EVGA SuperNOVA G2 750W		$100
Mobo	Asus X99A II		$230
CPU	Intel Core i7-5820K		$390
Cooler	Corsair H100i v2		$105
GPU	MSI GeForce GTX 1080 Sea Hawk 8GB	**NEW**	$740
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4-2666		$140
SSD	1.2TB Intel 750 Series PCIe SSD	**NEW**	$830
HDD	4TB WD Black 7,200rpm 3.5-inch SATA		$222
OS	Windows 10 Home 64-bit OEM	**NEW**	$100

Approximate Price: $3,027

UPGRADE OF THE MONTH

GEFORCE GTX 1060 3GB

It's all about bringing those pixels to the masses, and Nvidia has nailed it with the 3GB variant of the GTX 1060. Who'd have thought that just a simple decrease in core count and memory capacity would yield such a powerful and well-priced card? Pricing AMD out of the mid-range for the moment, and with not a single Founder's Edition in sight, getting hold of a 3GB card as an upgrade is likely to be the best purchase to make.

$200 (cheapest), $220 (MSI, pictured), www.nvidia.com

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus Holiday issue following December issue, by Future US, Inc., One Lombard Street, Suite 200, San Francisco, CA 94111. Phone: (650) 872-1642. Fax: (650) 872-2207. Website: www.futureus.com. Periodicals postage paid in San Bruno, CA, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $24; Canada: US$40; Foreign: US$40. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 5852, Harlan, IA 51593-1352. Standard Mail enclosure in the following editions: None. Ride-Along enclosure in the following editions: None. Returns: IMEX Global Solutions, PO Box 25542, London, ON N6C 6B2, Canada. Future US, Inc. also publishes *@Gamer*, *Mac|Life*, *The Official Xbox Magazine*, and *PC Gamer*. Entire contents copyright 2016, Future US, Inc. All rights reserved. Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in *Maximum PC*. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of *Maximum PC*. Products named in the pages of *Maximum PC* are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.

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